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L2 word recognition among late bilinguals: does modality matter?

Investigation of the modality effect in English second language among typical and dyslexic-readers.

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Abstract

This thesis work investigated the impact of modality on second language (L2) word recognition among French-English late bilinguals, involving a control in mother-tongue (L1) and a comparison with English native-speakers. In other words, this work assessed: a) the extent to which word presentation modality (*i.e.*, written or oral) influences their recognition accuracy and latencies; and b) to which degree orthographic and phonological lexical representations are connected to each other. Given the specificities of cognate words – *i.e.*, translation equivalents sharing orthographic more than phonological forms – the interaction between modality and cognate effects was of major interest to deal with these issues in L2. To take into account the level of L2 proficiency during L2 word recognition, the present work adopted a cross-sectional perspective, involving university and middle-school students. Besides, to take into consideration L1 reading efficiency, a comparison of typical and dyslexic-readers was included. Various configurations of a cross-modal repetition paradigm, involving a masked priming paradigm, were designed to: a) distinguish the effects on word recognition accuracy and latencies; and b) allow the investigation of various aspects of connections between orthographic and phonological lexical representations. Results highlighted a modality effect in L2, in favour of the written modality, among late bilinguals. Dyslexic-readers presented also a modality effect in favour of the written modality in L2, despite their difficulties with written stimuli processing. This work compared cognate word recognition across modalities and displayed a double-sided cognate effect: facilitatory in written modality and inhibitory in oral one. Besides, language features were crucial during L1 word recognition, English students presenting a modality effect in favour of the written modality in L1, whereas French students did not. Finally, the robustness of the links between orthographic and phonological representations in L1 and in L2 among typical and dyslexic-readers was interpretated in the light of the most relevant psycholinguistic models of bilingual word recognition, demonstrating the need to adapt those models to the population of dyslexic-readers.

Keywords: late bilinguals; modality effect; cognate words; developmental dyslexia.

Résumé

Ce travail de thèse a étudié l'impact de la modalité sur la reconnaissance des mots en langue seconde (L2) chez des bilingues tardifs français-anglais, incluant un contrôle en langue maternelle (L1) et une comparaison avec des anglophones natifs. En d'autres termes, ce travail a évalué : a) l'influence de la modalité de présentation des mots (*i.e.*, écrite ou orale) sur la précision et les latences de leur reconnaissance ; et b) dans quelle mesure les représentations lexicales orthographiques et phonologiques sont connectées entre elles. Étant donné les spécificités des mots cognates – *i.e.*, des équivalents de traduction partageant les formes orthographiques plus que phonologiques – l'interaction entre l'effet de modalité et l'effet cognate était d'un intérêt majeur pour traiter ces questions en L2. Pour prendre en compte le niveau de compétence en L2 lors de la reconnaissance de mots en L2, ce travail a adopté une perspective cross-sectionnelle, impliquant des étudiants d'université et de collège. En outre, pour prendre en compte l'efficacité de la lecture en L1, une comparaison entre des lecteurs typiques et dyslexiques a été incluse. Différentes configurations d'un paradigme de répétition cross-modale, impliquant un paradigme d'amorçage masqué, ont été conçues pour : a) distinguer les effets sur la précision et les latences de reconnaissance des mots ; et b) permettre l'investigation de divers aspects des connections entre les représentations lexicales orthographiques et phonologiques. Les résultats ont mis en évidence un effet de modalité en L2, en faveur de la modalité écrite, chez les bilingues tardifs. Les lecteurs dyslexiques ont également présenté un effet de modalité en faveur de la modalité écrite en L2, malgré leurs difficultés à traiter les stimuli écrits. Ce travail a comparé la reconnaissance de mots cognates selon la modalité et a montré un effet cognate à double aspect : facilitateur dans la modalité écrite et inhibiteur dans la modalité orale. Par ailleurs, les caractéristiques de la langue ont été cruciales lors de la reconnaissance des mots en L1, les étudiants anglais présentant un effet de modalité en faveur de la modalité écrite en L1, alors que les étudiants français n'en avaient pas. Enfin, la robustesse des liens entre les représentations orthographiques et phonologiques en L1 et en L2 chez les lecteurs typiques et dyslexiques a été interprétée à la lumière des modèles psycholinguistiques de reconnaissance de mots en contexte bilingue les plus pertinents, démontrant la nécessité d'adapter ces modèles à la population des lecteurs dyslexiques.

Mots-clés : bilingues tardifs ; effet de modalité ; mots cognates ; dyslexie développementale.

Résumé substantiel en français

Dans le contexte actuel de mondialisation, la maîtrise d'une langue étrangère est devenue cruciale pour l'intégration socio-professionnelle de chaque individu. C'est pourquoi les pouvoirs publics ont fait de l'enseignement d'une langue seconde (L2) l'une de leurs priorités, au niveau national, mais également européen. Pourtant, très peu de français se déclarent capables de suivre une conversation dans une autre langue que leur langue maternelle (L1). Par ailleurs, bien que la maîtrise d'une langue nécessite des compétences de communication à la fois orale et écrite, les modalités pratiques de l'enseignement de la L2 en contexte scolaire sont souvent caractérisées par une faible exposition à la L2 et par une prédominance des supports écrits. Ces conditions semblent peu favorables au développement de compétences de communication orale, tout comme elles paraissent particulièrement défavorables pour les individus présentant des difficultés de traitement des stimuli écrits, et notamment pour les individus dyslexiques. C'est pourquoi ce travail de thèse a étudié l'impact de la modalité sur la reconnaissance des mots en langue seconde (L2) chez des bilingues tardifs français-anglais, incluant un contrôle en langue maternelle (L1) et une comparaison avec des anglophones natifs, ainsi que la prise en compte des compétences de lecture en L1 via la comparaison entre des lecteurs typiques et dyslexiques.

Le chapitre 1 présente les caractéristiques de la reconnaissance de mots en L2 chez les lecteurs typiques bilingues tardifs, au travers d'une discussion concernant les diverses définitions et classifications du bilinguisme retrouvées dans la littérature scientifique. Afin de mieux comprendre les particularités de la reconnaissance de mots en L2, la littérature scientifique du domaine est ensuite analysée sous le spectre des divers modèles psycholinguistiques de reconnaissance de mots en contexte bilingue. La plupart de ces modèles concernant surtout des bilingues très compétents, l'accent est mis tout particulièrement sur ceux qui tiennent compte de la compétence en L2, à savoir les modèles BIA-d et Multilink. Ceux-ci sont donc ensuite pris comme référence, même si aucun des modèles existants ne semble parfaitement adapté à la situation des bilingues tardifs ayant appris la L2 en contexte scolaire.

Bien que la littérature regorge d'études concernant la reconnaissance de mots en L2, la majorité d'entre elles n'ont pris en compte qu'une seule modalité dans la réalisation des tâches expérimentales. L'objectif de ce travail de thèse étant l'analyse de l'impact de la modalité,

l'intérêt de l'utilisation des mots cognates (mots apparentés entre deux langues, correspondant à des équivalents de traduction partageant leur forme orthographique de manière partielle – cognates non identiques : tomate / tomato – ou totale – cognates identique : film / film) dans ce cadre est ensuite démontré. En effet, en raison du plus grand partage orthographique que phonologique que ces équivalents de traduction représentent, ils semblent particulièrement pertinents pour distinguer l'impact de la modalité dans la reconnaissance de mots en L2. Cependant, très peu d'études se sont attachées à l'analyse de cette question.

Le chapitre 2 est ensuite dédié aux particularités de la reconnaissance de mots dans la dyslexie développementale. La prévalence de la dyslexie développementale en France est telle que l'enseignement de la L2 a lieu dans des classes contenant en moyenne un ou deux lecteurs dyslexiques. Leurs difficultés en L1 étant également observées en L2, ce chapitre vise à mieux comprendre les difficultés présentées en L1, avant de commencer l'évaluation de leurs difficultés en L2. Après une brève présentation de la définition et des particularités de la dyslexie développementale, le modèle de Coltheart est défini comme référence pour la compréhension des diverses difficultés présentées par les lecteurs dyslexiques, notamment dans la reconnaissance de mots en L1. La littérature scientifique de la reconnaissance de mots écrits en L1 chez les lecteurs dyslexiques est ensuite explorée sous le spectre du modèle de Coltheart. Enfin, ce chapitre aborde la question de la dyslexie développementale chez les bilingues tardifs, démontrant que ce champ de recherche est encore sous-développé et nécessite des études complémentaires, étant données les caractéristiques et spécificité de cette population, à qui l'application des modèles décrits au chapitre 1 pour les lecteurs experts semble particulièrement difficile, voire inappropriée.

La section théorique de ce travail de thèse s'achève alors par la présentation des questions de recherche et hypothèses. Ainsi, ce travail a évalué : a) l'influence de la modalité de présentation des mots (*i.e.*, écrite ou orale) sur la précision et les latences de leur reconnaissance ; et b) dans quelle mesure les représentations lexicales orthographiques et phonologiques sont connectées entre elles. Étant donné les spécificités des mots cognates – *i.e.*, des équivalents de traduction partageant les formes orthographiques plus que phonologiques – l'interaction entre l'effet de modalité et l'effet cognate était d'un intérêt majeur pour traiter ces questions en L2. Pour prendre en compte le niveau de compétence en L2 lors de la reconnaissance de mots en L2, ce travail a adopté une perspective cross-sectionnelle, impliquant des étudiants d'université et de collège. En outre, pour prendre en compte l'efficacité de la lecture en L1, une comparaison entre des lecteurs typiques et dyslexiques a été incluse.

Différentes configurations d'un paradigme de répétition cross-modale, impliquant un paradigme d'amorçage masqué, ont ainsi été conçues pour : a) distinguer les effets sur la précision et les latences de reconnaissance des mots ; et b) permettre l'investigation de divers aspects des connections entre les représentations lexicales orthographiques et phonologiques.

Le chapitre 3 débute la section expérimentale par un avant-propos permettant de présenter en détails certains aspects communs à toutes les études expérimentales menées. Ainsi, les considérations éthiques sont abordées, tout comme les particularités de la réalisation de ce travail au cours de la crise sanitaire liée à la pandémie de COVID-19. Par ailleurs, la nécessité de disposer d’une base de données des fréquences lexicales des mots anglais au cours de l’apprentissage de l’anglais en tant que L2 en contexte scolaire en France est présentée, en lien avec le projet ANR APPREL2. Ce travail de thèse a en effet comporté la création d’une ébauche de cette base de données, afin de permettre une sélection adaptée des stimuli utilisés dans les diverses études expérimentales.

Des questionnaires spécifiques ont également été créés, pour les adultes et pour les collégiens. Ceux-ci ont été testés et validés par des études pilotes. Le choix du test de positionnement en langue Dialang est ensuite expliqué, par similarité avec l’étude princeps de Veivo en 2015. Afin d’en valider la pertinence par comparaison au test Lextale plus couramment utilisé, une étude sur 64 adultes français a été menée, démontrant une très forte corrélation positive entre les résultats de ces deux tests. Finalement, le chapitre 3 se termine par l’exposition du cadre de l’analyse des données, avec la définition des diverses variables dépendantes utilisées, ainsi que l’explication de l’analyse par modélisation à effets mixtes et sa validation par statistique bayésienne.

Le chapitre 4 est dévolu à l’expérience 1, concernant l’impact de la modalité sur la précision de reconnaissance des mots de L2, et l’interaction de l’effet de modalité attendu avec l’effet cognate. Cinq groupes de participants ont été constitués pour cette étude : a) des étudiants français lecteurs typiques ; b) des étudiants français, avec une comparaison entre lecteurs typiques et dyslexiques ; c) des collégiens français lecteurs typiques ; d) des collégiens français, avec une comparaison entre lecteurs typiques et dyslexiques ; et e) des étudiants écossais lecteurs typiques. Ces participants ont réalisé des tâches de décision lexicale en anglais, à l’oral et à l’écrit, avec un contrebalancement de l’ordre de présentation des modalités entre les participants, et ce au cours de deux études complémentaires : une étude non-cognate dans laquelle les listes de stimuli ne contenaient que des items non-cognates, et une étude cognate dans laquelle les listes de stimuli comportaient à la fois des items cognates et non-cognates. L'objectif de cette expérience 1 étant l'analyse de la précision de reconnaissance des mots, les items ont été sélectionnés sur des gammes de fréquence relativement faibles, afin d'éviter tout effet plancher ou plafond. Cette expérience a mis en exergue l'existence d'un effet de modalité dans la reconnaissance de mots en L2, avec une reconnaissance plus précise des mots écrits que des mots parlés. De manière tout à fait surprenante, les lecteurs dyslexiques (collégiens, comme étudiants) présentaient également un effet de modalité en faveur de l'écrit, ce qui pouvait être en lien avec leurs difficultés à apprendre les correspondances orthographe-phonologie spécifiques de la L2 en raison de leur déficit phonologique, mais aussi avec les modalités pratiques de l'apprentissage en contexte scolaire, ou encore les caractéristiques intrinsèques de la langue (i.e., son inconsistance orthographique ou l'incongruence inter-langue. Ces trois hypothèses peuvent bien sûr être complémentaires.

L'effet de modalité observé interagissait avec la compétence en L2, mais uniquement dans l'étude cognate, démontrant l'impact des mots cognates sur les liens entre effets de modalité et de compétence. Par ailleurs, une interaction entre modalité et statut cognate a pu être mise en évidence, indiquant que le classique effet de facilitation cognate devait être quelque peu modéré, celui-ci étant clairement existant à l'écrit, mais plus ambigu à l'oral.

Afin de contrôler les effets observés en L1, le chapitre 5 présente l'expérience 2, menée auprès des mêmes participants, avec le même paradigme expérimental mais en L1, avec des mots rares. Comme attendu, cette expérience n'a mis en évidence aucun effet de modalité en L1 français. A contrario, un effet de modalité semblable à celui observé en L2 anglais a été mis en exergue en L1 anglais. Ceci témoigne de l'importance des caractéristiques intrinsèques de chaque langue dans la reconnaissance de mots. Ainsi, la plus grande inconsistance orthographique de l'anglais par rapport au français pourrait être à l'origine de cette différence de résultats. Cependant, cela pourrait aussi être lié à l'inconsistance de prononciation des mots selon l'origine géographique des individus, d'autres recherches étant nécessaires pour distinguer ces diverses possibilités.

Les expériences 1 et 2 ayant été menées dans le but d'analyser la précision de reconnaissance des mots, une analyse précise des latences n'était pas possible, celle-ci nécessitant des critères de sélection différents des items. Le chapitre 6 présente ainsi l'expérience 3, visant à étudier l'impact de la répétition cross-modale sur les latences de reconnaissance des mots de L2. Étant donné le contexte sanitaire, cette étude a été intégralement réalisée en ligne. Seuls les trois groupes de participants adultes ont ainsi pu être inclus dans l'expérience. Après une phase d'exposition à 80 items dans une modalité, les participants ont réalisé une tâche de décision lexicale dans l'autre modalité, avec 40 items présentés dans la phase d'exposition et 40 items nouveaux. L'ordre de présentation des modalités a été contrebalancé entre les participants. Étant données les différences de latences entre les modalités, liées aux différences de processus de traitement, les résultats ont été analysés séparément pour chaque modalité. Comme attendu, un effet de la répétition cross-modale a été mis en évidence lors de la phase de test à l'écrit, indiquant un bénéfice de la modalité orale sur la modalité écrite. La présentation d'un mot parlé anglais active donc une représentation phonologique, qui permet d'accélérer la reconnaissance secondaire du même mot à l'écrit, la représentation orthographique associée ayant été pré-activée, via les liens existants entre les diverses représentations lexicales. Par ailleurs, un même effet a pu être démontré lors de la phase de test à l'oral. Ainsi, ces liens entre représentations lexicales d'un même mot sont robustes et bidirectionnels. Concernant les lecteurs dyslexiques, cette expérience a démontré leur sensibilité équivalente aux lecteurs typiques à cette répétition cross-modale lors de la phase de test à l'oral, alors que leurs représentations phonologiques ne semblent pas permettre la pré-activation des représentations orthographiques associées.

Afin de contrôler ces effets en L1, le chapitre 7 présente l'expérience 4, menée auprès des mêmes participants, avec le même paradigme expérimental mais en L1. Comme attendu, aucun effet de répétition cross-modale n'a pu être observé en L1, que ce soit concernant les lecteurs typiques ou les lecteurs dyslexiques.

Les expériences 1 à 4 étant basées sur des paradigmes expérimentaux proposant une répétition cross-modale des mots à l'échelle de la liste, l'analyse précise des liens entre représentations orthographiques et phonologiques des mots était impossible à l'échelle de l'item. Le chapitre 8 présente donc l'expérience 5, basée sur un paradigme d'amorçage masqué de répétition intermodale. Deux temps de présentation des amorces ont été comparés (50 et 67 ms) afin de pouvoir distinguer l'effet du traitement phonologique de l'amorce écrite sur la reconnaissance des mots parlés. Seuls des lecteurs typiques ont pris part à cette expérience. Les cibles étaient reconnues plus rapidement après les amorces reliées qu'après les amorces non reliées. Ceci témoigne de la robustesse des liens entre les représentations orthographiques et phonologiques des mots de L2. Par ailleurs, cet effet d'amorçage était de plus grande amplitude pour le temps de présentation des amorces le plus long. Ainsi, lorsque le temps de présentation de l’amorce est suffisamment long pour permettre un traitement phonologique, la représentation phonologique alors pré-activée permet une reconnaissance plus rapide de la cible parlée.

Ce manuscrit de thèse se termine par une discussion générale reprenant les objectifs principaux de ce travail et les résultats les plus marquants des diverses expériences. Ces résultats sont ensuite discutés à la lumière de la littérature existante dans le domaine, en distinguant les résultats des lecteurs typiques et dyslexiques. Enfin, des propositions d’adaptation du modèle Multilink sont évoquées. Bien que probablement impossibles à toutes implémenter dans un même modèle, elles permettent de mieux comprendre comment les résultats obtenus dans les diverses expériences de ce travail de thèse pourraient être pris en considération lors de l’adaptation de ce type de modèle à des populations spécifiques comme celles des bilingues tardifs et/ou des lecteurs dyslexiques.

Ainsi, les résultats des diverses expériences de ce travail de thèse ont mis en évidence un effet de modalité en L2, en faveur de la modalité écrite, chez les bilingues tardifs. Les lecteurs dyslexiques ont également présenté un effet de modalité en faveur de la modalité écrite en L2, malgré leurs difficultés à traiter les stimuli écrits. Ce travail a comparé la reconnaissance de mots cognates selon la modalité et a montré un effet cognate à double aspect : facilitateur dans la modalité écrite et inhibiteur dans la modalité orale. Par ailleurs, les caractéristiques de la langue ont été cruciales lors de la reconnaissance des mots en L1, les étudiants anglais présentant un effet de modalité en faveur de la modalité écrite en L1, alors que les étudiants français n’en avaient pas. Enfin, la robustesse des liens entre les représentations orthographiques et phonologiques en L1 et en L2 chez les lecteurs typiques et dyslexiques a été interprétée à la lumière des modèles psycholinguistiques de reconnaissance de mots en contexte bilingue les plus pertinents, démontrant la nécessité d'adapter ces modèles à la population des lecteurs dyslexiques.

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List of abbreviations

AIC	Akaike Information Criterion
ANR	National Research Agency
Bayes_R^2	Bayesian version of the R^2
BF	Bayes Factor
BIA	Bilingual Interactive Activation model
BIAd	Bilingual Interactive Activation developmental model
BIMOLA	BIlingual MOdel of Lexical Access
BLINCS	Bilingual Language Interaction Network for Comprehension of Speech
CEFR	Common European Framework of Reference
cf.	Confer
CNIL	Commission for Information Technology and Civil Liberties
CrI	Credible Interval = HDI
d’	Discrimination rate between words and pseudowords
DD	Developmental Dyslexia
DL	Dialang Level
DRC	Dual-route cascaded model of visual word recognition and reading aloud
Dys	Dyslexic-readers
e.g.,	For example,
EFL	English as a Foreign Language
En	English
ER_3	Error Rate corresponding to a Random Response
Et al.	Et alter
Fr	French
GLMM	Generalized linear mixed-effect modelling
GPC	Grapheme-Phoneme Correspondences or Conversion
HD	High definition
HDI	Highest Density Intervel = CrI
Hz	Hertz
i.e.,	Id est
L1	First language, Mother tongue
L2	Second language
L3	Third language
LDT	Lexical Decision Task
LMM	Linear mixed-effect modelling
M / Mid	Middle-school students
MHM	Modified Hierarchical Model
min	Minutes
mldTE	Minimum Levenshtein distance between translation equivalents

ms	Milliseconds
n	Number of stimuli in the task
old20	Orthographic Levensthein distance with the 20 closest neighbours
OPM	Orthography-to-Phonology Mappings
p	p value
pld20	Phonological Levenshtein distance with the 20 closest neighbours
r	Correlation coefficient
RHM	Revised Hierarchical Model
SAM	Shared Asymmetrical Model
SD	Standard Deviation
SE	Standard Error
t	Student test
Typ	Typical-readers
U / Univ	University students
vs	Versus

« Chérissez votre curiosité et cultivez votre imagination.
Ayez confiance en vous.
Ne laissez pas les autres vous imposer des limites.
Osez imaginer l'inimaginable. »

Shirley Ann Jackson, *Conseils aux futurs scientifiques*

« One language sets you in a corridor for life.
Two languages open every door along the way. »

Frank Smith

« Bilingualism is an incredible gift to give to a child.
It goes beyond just learning another language.
It broadens mental development, thought patterns, and world perspective. »

Bilingual Mom in Oregon to Dear Abby,
via Spanglish Baby

Foreword

With this thesis work, we wanted to establish a basis for the research on the impact of modality on second language (L2) word recognition, taking into consideration both the level of proficiency in L2 and the reading efficiency in mother tongue (L1). Concerning L2 proficiency, we analysed its direct impact on L2 word recognition within groups (among late bilinguals, either university or middle-school students) and focused between groups on a cross-sectional perspective of L2 learning in an academic context, characterized by a predominance of written materials. Regarding L1 reading efficiency, we compared typical and dyslexic-readers, learning conditions mentioned above not appearing to be suitable for dyslexic-readers.

The general objectives of this work are: a) to evaluate the impact of word presentation modality (oral *vs*. written) on the accuracy of L2 word recognition, the first step in lexical processing, among adult late L2 learners from a large range of proficiency; b) to highlight a change of this impact with the increase of proficiency, through a cross-sectional perspective, comparing adult and grades 8 and 9 late L2 learners; c) to determine how L1 reading efficiency interacts with the modality effect in L2 *via* a comparison of L2 word recognition among typical (*i.e.*, without reading difficulties) and dyslexic-reader (*i.e.*, presenting difficulties in written stimuli processing) late L2 learners; d) to assess the robustness of the links between L2 orthographic and phonological lexical representations, allowing a benefit from one modality over the other, highlighted through an effect on latencies during a cross-modal paradigm; and e) to analyse the extent to which L2 orthographic code influence L2 spoken word recognition.

Therefore, this work proposes a first assessment of the impact of practical learning conditions of English as an L2 (through the impact of word presentation modality) on L2 word recognition skills of French learners, focusing on the learning in a school context in France, and taking into account the diversity of learners in terms of L1 reading efficiency or L2 proficiency.

General introduction

In this time of growing Globalization, the modern Olympic Games, Internet, social networks and the frequent linguistic borrowings (*e.g.*, anglicisms representing approximately 3% of the lexical types in a French corpus - Harris, 2010), foreign language proficiency has become a major challenge for each individual, and especially for his/her socio-professional integration. Indeed, since the emergence of the European Union during the 20th century, and even more widely today, the links between nations have been greatly favoured, whether in the professional field (Chancelade et al., 2015; Legendre, 2004) or in private life, and also for leisure activities.

Therefore, public policies have made second language (L2) teaching one of their core issues in order to enable each of their citizens to communicate and interact effectively with their foreign peers Holdsworth, 2003; and for French recent public policy: Ministère de l'Education Nationale, de la Jeunesse et des Sports, 2019). Indeed, according to the European Commission in 2012, the European Union encourages its citizens to learn several languages, so that every European citizen will in the long term have practical skills in at least three languages including his/her mother-tongue (L1).

Interestingly, governments are not alone in considering foreign language proficiency as a success factor. For example, 84% of Europeans believe that everyone should be able to speak at least one language other than their L1 (European Commission, 2012). But, even though more than one out of two Europeans say they feel able to hold a conversation in at least one language other than their L1, only 44% of European citizens consider they would have sufficient oral and written comprehension skills to follow a television or radio program and to read a newspaper article in another language than their L1 (European Commission, 2012). Considering foreign languages, English remains the most widely spoken foreign language at the European level (with 38% of European citizens, European Commission, 2012 – *vs*. 71% of the world's population, *Ethnologue, Languages of the World*, 2020) and is considered by 67% of Europeans as one of the two most useful languages for them (European Commission, 2012).

In France, the report is indisputable. Only 19% of French citizens claim to be able to hold a conversation in another language than their L1, this other language being English for 39% of them (European Commission, 2012). Only one out of four French people think they can follow the news in English on the radio or television, and only one out of three think they can read articles in English daily newspapers (European Commission, 2012). And even though nearly eight out of ten French people find English useful for personal development (and especially for work – 61% of French people), and more than nine out of ten feel that it is the language that children should learn for their future, nearly half of French people lack the motivation to learn foreign languages (European Commission, 2012).

This lack of motivation (not only for French people, but also for Europeans in general) probably explains why foreign language learning is mostly limited to the academic context (*i.e.*, at school), where public policies have made it mandatory. Indeed, 68% of Europeans learned their foreign languages at school, when it is the case for 78% of French people (European Commission, 2012). Nonetheless, only four out of ten French people believe that learning at school is the most effective way to learn a foreign language (European Commission, 2012).

It is commonly accepted that the mastery of a language (both native and foreign) is based on both oral and written communication skills. Nevertheless, because of the practicalities of L2 learning in a school context, this learning is characterized in most countries by a low exposure to the L2 (*i.e.,* 3 hours per week, about 30 weeks per year in France) and by a predominance of written materials, conditions that do not appear to be propitious to the development of language skills – particularly oral communication skills – and which could be a possible explanation for the so small proportion of French people who feel they are able to hold a conversation in L2. Furthermore, this bias in exposure, in favour of the written modality, during L2 learning at school appears particularly not suitable for people presenting difficulties in written stimuli processing.

In France, 11.5% of young people participating in the "Journée Défense et Citoyenneté" encounter reading difficulties (Chabanon, 2020). Moreover, in September 2020[1], all sixth-grade students were assessed in French and Mathematics on a digital device in France (*i.e.*, 800,000 students in nearly 7,000 middle-schools, according to the "note d'information 2021" – Andreu et al., 2021). It was the first time that a reading fluency test had been included in this national assessment. While more than half of the students reach the objective of 120 words per minute, three out of ten show weaknesses (90 to 120 words per minute only) and more than 15% do not reach 90 words read per minute (which is the objective at the end of the third grade).

Several aetiologies can be considered for these reading difficulties, including a developmental disorder of written language, or developmental dyslexia (DD). In France, depending on the studies, 6 to 8% of children present a DD (Barrouillet et al., 2007 – 10% at the world level according to Cramer in 2016). Therefore, L2 learning in a school context takes place in classes with one or two dyslexic-readers in average. That is why it seems crucial to take into account this reading impairment during L2 learning at school.

This was the particular background to the current project. This thesis work aims at testing both oral and written skills of French people in English word recognition. Indeed, word recognition (both oral and written) is the first stage of lexical processing, allowing the access

[1] Note that this assessment took place after the March-April 2020 lockdown episode.

to lexical knowledge, which cognitive process has attracted much less attention than it deserved until the last 25 years (Koda, 1996). To develop their language skills, people need to create links between orthographic and phonological lexical representations. This work thus aims at evaluating the impact of modality on L2 word recognition and the robustness of the links between L2 orthographic and phonological lexical representations, among French-English late bilinguals. To take into consideration L1 reading efficiency, which could modulate the impact of modality on L2 word recognition, four out of our five experiments included a comparison between dyslexic and typical-readers. In addition, we also pursued some objectives concerning the influence of the disparities in L2 proficiency between learners. We therefore included in three out of our five experiments, from a cross-sectional perspective, a comparison between middle-school and university students. Finally, in order to take into account L1 disparities at the European level in L2 learning in an academic context, we involved in our five experiments English native-speakers.

This thesis manuscript will be divided in two main parts: the theoretical and the experimental sections. In the course of the following theoretical section, we will detail our research questions and hypotheses, with regard to the existing literature about: a) L2 word recognition among typical-readers; and b) the main characteristics of dyslexic-readers, especially when confronted with L2 word recognition.

THEORETICAL SECTION

Chapter 1. Second language word recognition among typical-readers.

"Multilingualism promotes culture. A culturally diverse child is better prepared to participate and compete in a global society."
Maritere R. Bellas

Defining bilingualism (or multilingualism) is not straightforward. Are bilinguals only those who are equally proficient in both languages? What about a person who can understand a language other than their L1, but who does not know how to produce it perfectly? Can the level of proficiency be the only criterion for assessing bilingualism or should we also take into account the use made of both languages? Is self-assessment through questionnaires a valid criterion for defining bilingualism? Can the degree of bilingualism change throughout an individual's life? These are part of the questions that researchers in the field must try to answer. The next section will therefore be devoted to a brief overview of the definitions and classifications of bilingualism that have already emerged in the literature. We will then look at the major aspects of L2 word recognition, through a description of the main psycholinguistic models. We will end this chapter with experimental results concerning the different effects linked with L2 word recognition.

1.1. Bilingualism: definition and classification.

Defining what being bilingual means is a complex problem since various factors (linguistic, cultural, psychological and social ones) must be taken into consideration (Hamers & Blanc, 1983; Perregaux, 1994). Two major trends are opposed concerning this definition: the maximalist and minimalist positions. The **maximalist position** is represented by Christophersen, in 1948, who described (and discussed this definition) the bilingual individual as "a person who knows two languages with approximately the same degree of perfection as unilingual speakers of those languages" (see also: Bloomfield, 1935). *A contrario,* the **minimalist position** seems more flexible. There, one finds Macnamara, in 1967, for whom an individual can be said to be bilingual if he/she has a minimum of L2 proficiency in at least one of the four language skills (*i.e.*, speaking, spelling, reading and comprehension). Between these two opposing major trends, there is a whole range of intermediate definitions along a ***continuum***. Noteworthy is the one of Grosjean, in 1994, who defines bilingual individuals as “those people who use two (or more) languages (or dialects) in their everyday lives”, independently of the mode and age of acquisition of each of these languages. To date, no definition is totally consensual. However, one thing is certain, perfect mastery of two languages is utopian (that of each individual's L1 being already particularly difficult for everyone). That is why it seems relevant to us to keep in mind this idea of a *continuum* when describing bilingualism. Thus, it is crucial to classify bilinguals/bilingualisms in order to define properly the characteristics of the population under consideration.

Several classifications were proposed throughout the literature, depending on the parameter used to differentiate bilingual individuals. We will here focus on the most relevant within the framework of our purpose. The first one considers the age of acquisition of both languages as a key factor, distinguishing between **simultaneous bilingualism** (acquisition of two languages simultaneously in a bilingual environment before the age of three - McLaughlin, 1995), **successive bilingualism** (acquisition of an L2 after the age of about three but before the completion of L1 acquisition - McLaughlin, 1995) and **late bilingualism** (late introduction of the L2 after the completion of L1 acquisition - during adolescence or adulthood - Adler, 1977; Moradi, 2014). Late bilingualism is less likely to result in a nativelike command of phonology and grammar than are the previous ones. In 1973, Lambert proposed another differentiation between an **additive bilingualism** (both languages being socially valued) and a **subtractive**

bilingualism (mainly experienced by immigrant communities, characterized by a social pressure not to use their ethnic language in favour of using a national language, the first being undervalued in relation to the second). These two types of bilingualism are associated, at least partially, with the existence of a balanced or unbalanced bilingualism. Indeed, additive bilingualism seems to be able to lead to an approximately equivalent and correct mastery of both languages, and therefore to a relatively **balanced bilingualism**. Subtractive bilingualism seems to lead only to an **unbalanced bilingualism**, with greater competence in the socially valued language than in the other (Lambert, 1955). However, a bilingual individual whose two languages are socially valued may also have an unbalanced bilingualism, especially when the L2 is learned lately (*i.e.*, for late bilinguals).

In this manuscript, we proposed to make also a distinction between **acquired bilingualism** (which refers to natural L2 learning in informal conditions – *e.g.*, within a bilingual family environment – taking place mostly though the oral modality) and **learned bilingualism** (being part of a more formal school didactic situation, mainly based on the written modality). Whatever the definition or classification used, it is commonly accepted that both oral and written communication skills are needed to ensure the mastery of a language, those skills depending on the efficacy of lexical processing. The next section will thus be devoted to the most relevant bilingual models of word recognition, the first stage of lexical processing, allowing to understand the main effects highlighted throughout the literature on L2 word recognition[2].

[2] In this manuscript, for greater clarity, the terminology "second language" or "L2" will be used to call attention to any language different from the L1, whatever the total number of languages learned. Moreover, the term "L2 learning" will refer to a formal learning in an academic context (L2 acquisition corresponding to an implicit acquisition taking place in informal conditions) and "late L2 learning" will refer to this type of formal learning in an academic context during adolescence or adulthood.

1.2. Bilingual models of word recognition.

In the field of bilingualism, one of the most influential models of L2 word processing is the **Revised Hierarchical Model** (RHM – Kroll & Stewart, 1994). This is a production model, designed to describe word processing during tasks such as translation. This model assumes the existence of two **separate lexicons**, one for each language, while the conceptual system (including semantic representations) is shared between languages. L1 lexical representations are strongly linked with the semantic level, whereas the connections between L2 lexical representations and concepts depend on the level of L2 proficiency. These assumptions of the RHM were strongly debated (Brysbaert & Duyck, 2010), that have led to new modelling proposals, such as the Shared Asymmetrical Model (SAM – Dong et al., 2005) or the Modified Hierarchical Model (MHM – Pavlenko, 2009)[3]. In addition, RHM is a production model which described the asymmetrical links between translation equivalents. It is important to note that a translation task necessitates a semantic processing, which is of a higher level of complexity than word recognition, the first stage of lexical processing, simply corresponding to one's identification of a stimulus as belonging to his/her mental lexicon (and thus being a real word, associated with different lexical representations: orthographic, phonological, semantic, syntactic, …).

As this thesis project focused on L2 word recognition among late bilinguals (*cf.* its title), assumed to be mostly unbalanced bilinguals, we will consider mainly **developmental models of L2 word recognition**, more adapted to this particular population. Indeed, most L2 models of word processing (such as RHM, Kroll & Stewart, 1994) only take into account highly proficient bilinguals. Models that include a developmental dimension therefore seem to be the most appropriate models to account for lexical learning in unbalanced bilinguals, as we will

[3] Those models precise the organization of the conceptual system, with common and specific elements between translation equivalents in the SAM, and the necessity of a conceptual reorganization in the MHM.

demonstrate below. However, these models are based on organizational models for fluent bilinguals, which should be described first. We will therefore begin this model overview with the Bilingual Interactive Activation model (BIA – Dijkstra et al., 1998; Grainger & Dijkstra, 1992; van Heuven et al., 1998).

1.2.1. The Bilingual Interactive Activation model.

1.2.1.1. The BIA model architecture.

In the early 1980s, monolingual interactive activation models of written word recognition were described (McClelland & Elman, 1986a, 1986b; McClelland & Rumelhart, 1981; Rumelhart & McClelland, 1982). These models highlighted a bidirectional flow of information between the lexical and sub-lexical processing levels. Based on the monolingual interactive activation model of McClelland and Rumelhart (1981), the **BIA model** (Dijkstra, Van Heuven, et al., 1998; Grainger & Dijkstra, 1992; van Heuven et al., 1998) includes four layers of nodes, corresponding to different levels of written language representation (letter features, letters, words and languages), which interact bidirectionally (see Figure 1 page 12) to describe the mechanisms of written word recognition in highly proficient bilinguals.

This model postulates the existence of a level of letter features, with 14 possible features for each letter position. When a visual input is presented to the model, it allows the activation of letter features for each position in the string. The features activated would then allow the activation of letter nodes (26 possible letters for each position in a word) at their respective positions, resulting in the identification of the letters constituting the visual input. The letters activated could in turn activate lexical entries (*i.e.,* word nodes) they are connected to. Nodes at each level, as well as of different levels, are connected between them. These connections allow for activation and/or inhibition, depending on their localisation. Indeed, word units are negatively interconnected. They can therefore inhibit each other’s activation. Letter units can activate all words containing them in the correct position, and inhibit words when there is a mismatch. Activated word nodes can then activate their language nodes, which send in turn top-down inhibition to words from the other language. With this model, words from both languages compete against each other through an **integrated lexicon**. There would thus be an initial phase of non-selective lexical access in relation to the language. In a second phase, a higher level of processing that codes the language would allow one of the two languages to be top-down filtered according to the context and the expectations of the individual. It should be noted that the words could be more or less easily activated according to their frequency of use, which would induce different interlanguage influences according to the level of proficiency of bilinguals in each of their languages as well as the rate of use of these languages (and also language exposure).

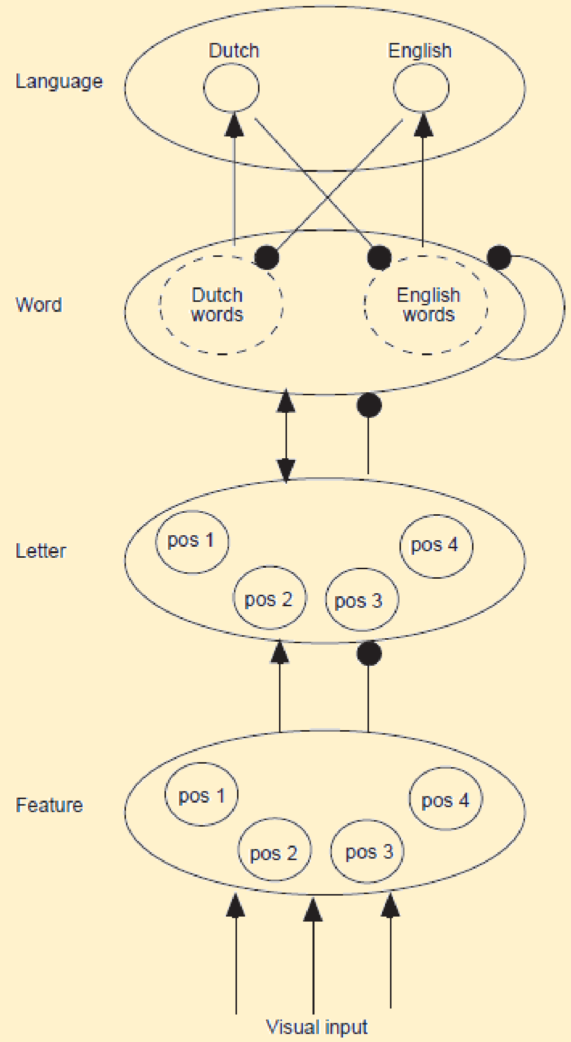

Figure 1. The Bilingual Interactive Activation (BIA) model (from Dijkstra, Van Heuven, et al., 1998). Excitatory connections are indicated by arrows (with arrow heads pointing in the direction of activation spreading), inhibitory connections by ball-headed lines.

1.2.1.2.Experimental validations of the BIA model.

The BIA model describing the mechanisms of written word recognition among highly proficient bilinguals, it is particularly relevant to analyse data from written lexical decision tasks. Many studies have thus analysed the specificities of L2 written word recognition, with reference to this model, through various paradigms based on lexical decision tasks.

Interestingly, this model assumes a shared lexicon between L1 and L2. Indeed, there were various studies highlighting a **co-activation** and a **lexical competition** between many word candidates, regardless of their belonging language (Brysbaert & Duyck, 2010), using neighbourhood (Meade et al., 2018; van Heuven et al., 1998) and homograph (Dijkstra, Van Heuven, et al., 1998) effects.

For example, Van Heuven et al., in 1998, proposed to 20 monolingual English-native speakers and 21 Dutch-English highly proficient bilinguals a written lexical decision task in English. The stimuli consisted in four-letter long English words and pseudowords spread over four orthographic neighbourhood conditions: large or small, in either Dutch or English. Orthographic neighbours were defined as words different from a target word by a single letter, respecting length and letter position (Coltheart, 1977). Findings highlighted a **lexicality effect**, with shorter response latencies for words than pseudowords, whatever the status of the participant (monolingual or bilingual). Moreover, even in a situation in which participants never used their L1, L1 neighbourhood had inhibitory effects on L2 word recognition, whereas L2 neighbourhood had facilitatory effects on it. This **L1 inhibitory orthographic neighbourhood effect** demonstrated that both L1 and L2 lexicons were activated, allowing a between-language lexical competition. This is in line with the initial phase of non-selective lexical access in relation to the language (see also: Meade et al., 2018). In 1992, Grainger and Dijkstra demonstrated also this non-selective lexical access in relation to the language through the existence of longer latencies for language decision than lexical decision among bilingual individuals. Indeed, this indicates that determining the language to which a word belongs is less automated among bilinguals than deciding whether or not a stimulus corresponds to a real word.

Additionally, in 2016, Oganian et al. conducted an experiment among 28 German native speakers highly proficient in English, with German and English written lexical decision tasks. The stimuli were 124 words and pseudowords in each language, from various lengths (3 to 6 letters). They showed a similar lexicality effect, with shorter response latencies and fewer errors for words than pseudowords. Moreover, they highlighted: a) a **language effect**, with shorter response latencies and fewer errors in L1 than in L2; and b) a **length effect**: the shorter the word length, the shorter the latency.

Therefore, there were numerous studies experimentally validating the assumptions of the BIA model. However, some empirical data cannot be explained with this model, in which phonology and semantics, for example, were not taken into consideration. Updated models were thus proposed, such as the following.

1.2.2. The Bilingual Interactive Activation plus model.

1.2.2.1. The BIA+ model architecture.

In 2002, Dijkstra and van Heuven proposed an updated version of the Bilingual Interactive Activation model (Dijkstra, Van Heuven, et al., 1998; Grainger & Dijkstra, 1992; van Heuven et al., 1998): the **Bilingual Interactive Activation plus model** (BIA+, see Figure 2 page 15, Dijkstra & van Heuven, 2002). This new version is an extension of the previous one, in which phonological and semantic lexical representations were added to the orthographic ones. As the BIA model, this model assumes a **shared lexicon** across languages, including orthographic representations (allowing cross-language orthographic neighbourhood effect on bilingual word recognition, van Heuven et al., 1998), as well as phonological and semantic representations (allowing also cross-language phonological and semantic overlap effects, as shown by Dijkstra et al., 1999; Jared & Kroll, 2001). One fundamental assumption of this model is the fact that those added phonological and semantic representations constitute a specific subsystem the activation of which is **delayed** compared to L1 representations.

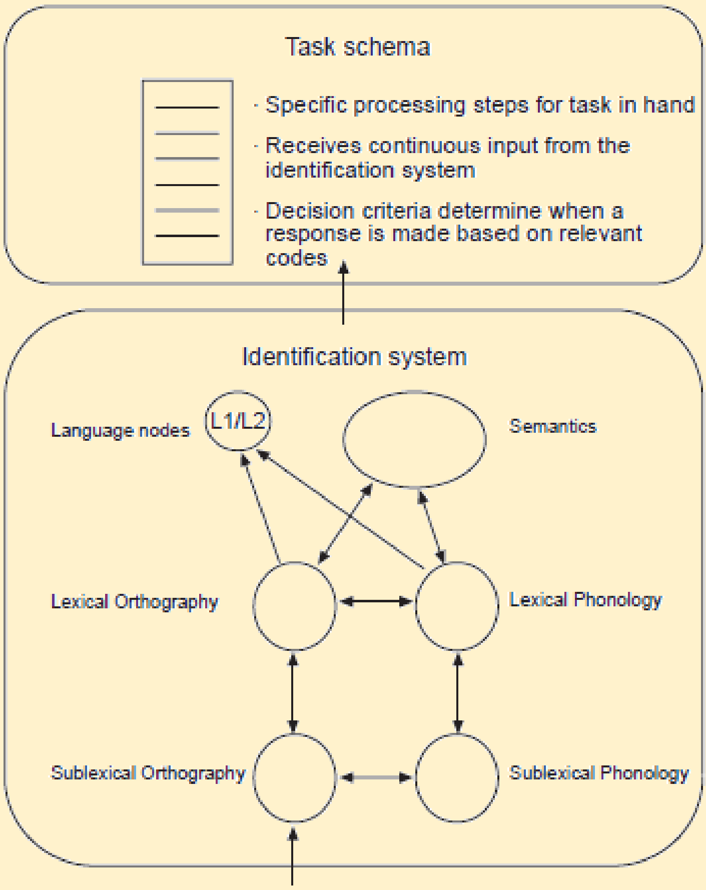

Figure 2. The BIA+ model for bilingual word recognition (from Dijkstra & van Heuven, 2002). Arrows indicate activation flows between representational pools. Inhibitory connections within pools are omitted. Language nodes could instead be attached to lemma representations between word form and meaning representations. Non-linguistic context only affects the task schema level.

Furthermore, the BIA+ model enabled a distinction between linguistic (affecting word-identification system) and non-linguistic (affecting task/decision system) context effects on performance, replacing the top-down inhibition mechanism from language nodes to word nodes proposed in the BIA model. We will not discuss this assumption of the BIA+ model, which is not relevant for the current project, and also not consensual, given that many studies demonstrated that the language of the last word processed determines the level of activation of the other words depending on their belonging language. Nevertheless, we will now show that this model was validated by a huge number of bilingual word recognition experiments.

1.2.2.2.Experimental validations of the BIA+ model.

In 2005, Duyck proposed to 22 Dutch-English bilinguals, having learned English in an academic context and with intermediate proficiency in English, a lexical decision task, with cross-lingual primes including pseudo-homophones, both in L1 and in L2. Those particular items are pseudowords which sound like real words when using orthography-to-phonology mappings (OPM) of one's language. For French and English languages example, the real English word "coffee" would be preceded by an L1 pseudo-homophone of its L1 translation equivalent "café", such as "caphé". Findings demonstrated that **cross-lingual pseudo-homophones facilitated** target recognition more from L1 to L2 than from L2 to L1, which is in line with the temporal delay assumption of the BIA+ model (Dijkstra & van Heuven, 2002).

In addition, Dijkstra et al. (1999) proposed to 30 Dutch-English university students a written lexical decision task involving English words varying in their semantic, orthographic and phonological similarities with Dutch words. They observed a **facilitatory effect of both cross-lingual semantic and orthographic overlaps**. On the contrary, phonological similarity was associated with an inhibitory effect. The fact that the three codes (semantic, orthographic and phonological) were able to affect latencies was interpretated as a proof of the highly interactivity of the bilingual processing system, notably because the experimental paradigm was built exclusively in English context (including instructions, …). More, the **inhibitory effect of phonological overlap** indicated that two distinct phonological representations were activated. Therefore, the written English words activated all compatible phonological representations, whatever the language, the non-identical representations activated competing at the lexical level, slowing word recognition. However, some other experimental results demonstrated the need to further develop the phonological subsystem of this type of model, in order to give an account to some results (see notably Jared & Kroll, 2001).

In 2010, Grainger et al. proposed a developmental version of this model of word recognition. Because this developmental version was designed to take into consideration late bilingual beginner learners, during L2 word recognition, it is therefore particularly suitable for this thesis project, aiming to analyse word recognition among intermediate proficiency late bilinguals. We will now detail this adapted model.

1.2.3. The Bilingual Interactive Activation - developmental model.

1.2.3.1. The BIA-d model architecture.

The **Bilingual Interactive Activation – developmental model** (BIA-d – Grainger et al., 2010) is, as its name suggests, a developmental version of the BIA (Dijkstra, Van Heuven, et al., 1998; Grainger & Dijkstra, 1992; van Heuven et al., 1998) and the BIA+ (Dijkstra & van Heuven, 2002) models, designed for late L2 learners. This model (see Figure 3 page 18) was designed to describe the lexicon organization evolution associated with proficiency increase among late L2 learners. At the beginning of L2 learning, this model assumes that the initial exposure to L2 creates connections between translation equivalents of both languages, mediating the links between L2 words and concepts. Progressively, with the upcoming L2 exposure, those connections are strengthened, while direct connections between L2 words and their appropriate semantic representations are established. This part of the model corresponds to the **Revised Hierarchical Model** (see section 1.2 page 10 – Kroll & Stewart, 1994). However, the direct connections between L2 words and semantic level are further enhanced, modulating the links between translation equivalents, up to the creation of inhibitory links allowing the global inhibition of the lexical forms of a language during the processing of items of the other language. This part of the model therefore corresponds more closely to the language node function of the **BIA model** (Dijkstra, Van Heuven, et al., 1998; Grainger & Dijkstra, 1992; van Heuven et al., 1998).

This model is particularly relevant for the purpose of this thesis project, aiming to analyse L2 word recognition among late French-English bilinguals having learned English in an academic context. Indeed, in this context, teachers indicate to learners that the new word is an L2 word and that it corresponds to a translation equivalent in L1 (this phase is called "**supervised learning**"). This type of exposure to the L2 tends to create and develop lexical links between translation equivalents. Then, with the increase of L2 exposure and use, direct links between L2 words and the semantic level are established and enhanced, reducing the necessity to refer to translation equivalents and making it easier to understand and produce the L2 (this phase is called "**unsupervised learning**").

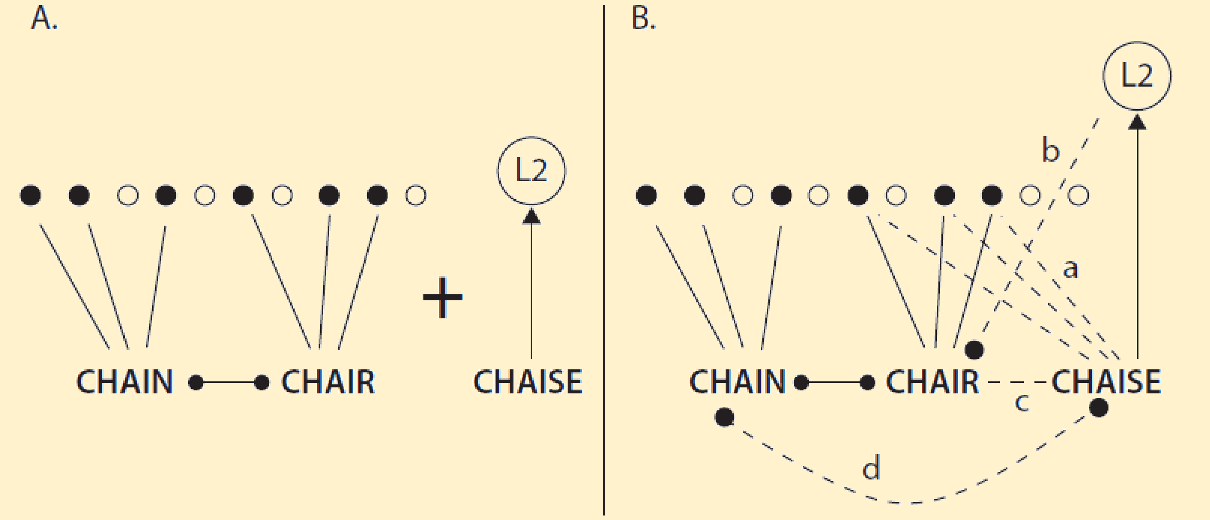

Figure 3. The developmental bilingual interactive-activation (BIA-d) model of 2nd language vocabulary acquisition (from Grainger et al., 2010).

1.2.3.2.Experimental validations of the BIA-d model.

Geyer et al. (2011) investigated the core assumption of the BIA-d model (Grainger et al., 2010) that **inhibitory connections between translation equivalents are developed as L2 proficiency increases**. This development of inhibition would imply a decrease of the translation priming between L1 and L2, the need to refer to translation equivalents being reduced as direct links between L2 words and semantic level are enhanced. The authors therefore compared the symmetrical priming – in both L1-to-L2 and L2-to-L1 directions – they observed among highly proficient bilinguals, on a task opposing cross-language translation priming effects and intralingual repetition effects, with the asymmetric priming between languages, in favour of the L2-to-L1 direction, observed by Alvarez et al. (2003) with the same paradigm among unbalanced bilinguals.

Moreover, the BIA-d model (Grainger et al., 2010) assumed that the links between L1 words and semantic level are stronger than direct links between L2 words and semantic level at the initial stage of L2 learning, and that the latter connections are enhanced when L2 proficiency increases. Aparicio et al. (2012) tested these hypotheses through an electrophysiological study of mixed semantic categorization task among trilingual individuals. They found lower latencies for the N400[4] component associated with L1 words, compared to those associated with L2 or L3 words. This was congruent with the first hypothesis, concerning the **stronger connection of L1 words, compared to the others, with semantic level**. The N400 components associated with L2 and L3 words did not differ in latencies, while a difference in their amplitudes was highlighted, this one being larger for L3 words. This **amplitude difference** was interpretated **as a consequence of the L2 and L3 levels of proficiency**.

Moreover, even if this model could also be applied to spoken word recognition, according to its authors themselves (Grainger et al., 2010), which is crucial for this thesis project, aiming to analyse the impact of L2 word presentation modality on word recognition, an interaction between modalities is not explicit in the BIA-d model, designed to describe the development of written lexical knowledge. The next section will be devoted to the description

[4] We won't detail in this manuscript this kind of electrophysiological data. Note that the N400 component reflects the semantic processing.

of a recent model, which also involved a phonological component: the Multilink model (Dijkstra et al., 2019).

1.2.4. The Multilink model.

1.2.4.1. The Multilink model architecture.

Recently, the **Multilink model** (Dijkstra et al., 2019), including also a phonological component, was proposed to take into account the level of proficiency in L2, during various tasks, especially involving specific word processing. Indeed, the language non-selective lexical access allows cross-language lexical competition between orthographic neighbours (van Heuven et al., 1998), themselves activating in turn their associated phonological representations (Coltheart et al., 2001). In the same time, these orthographic representations activate their associated semantic representations (Balota, 1994; Grainger, 2008), which spread this activation to all semantically related lexical units. Thus, the processing of cognate words (*i.e.,* translation equivalents that share orthographic overlap in L1 and L2) involves an activation of orthographic and phonological representations of those words in both languages. Those activated representations send then congruent activations to the shared semantic representations (Dijkstra et al., 2010), leading to the well-known **cognate facilitation effect** (see notably the section 1.3.1 page 25 for a brief review). However, the previous models did not implement cognate processing, while the Multilink model simulates **cognate and non-cognate word recognition**.

The Multilink model (see Figure 4 page 21) is a computational cognitive model which applies a specific algorithm to the symbolic representations of word forms and word meanings, including a large number of connections between those different representations. This model was designed in order to help the understanding of the mechanisms underlying bilingual word processing. In this model, a written input (blue underscore in Figure 4) activates several orthographic lexical representations (green underscores in Figure 4). The activated orthographic representations activate in turn their associated phonological (slashes in Figure 4) and semantic (in yellow in Figure 4) representations in both languages, included in an **integrated lexicon**. Each word representation is associated with a specific resting level activation, depending on its frequency of use. The resting level activations were adapted to take into account L2 proficiency.

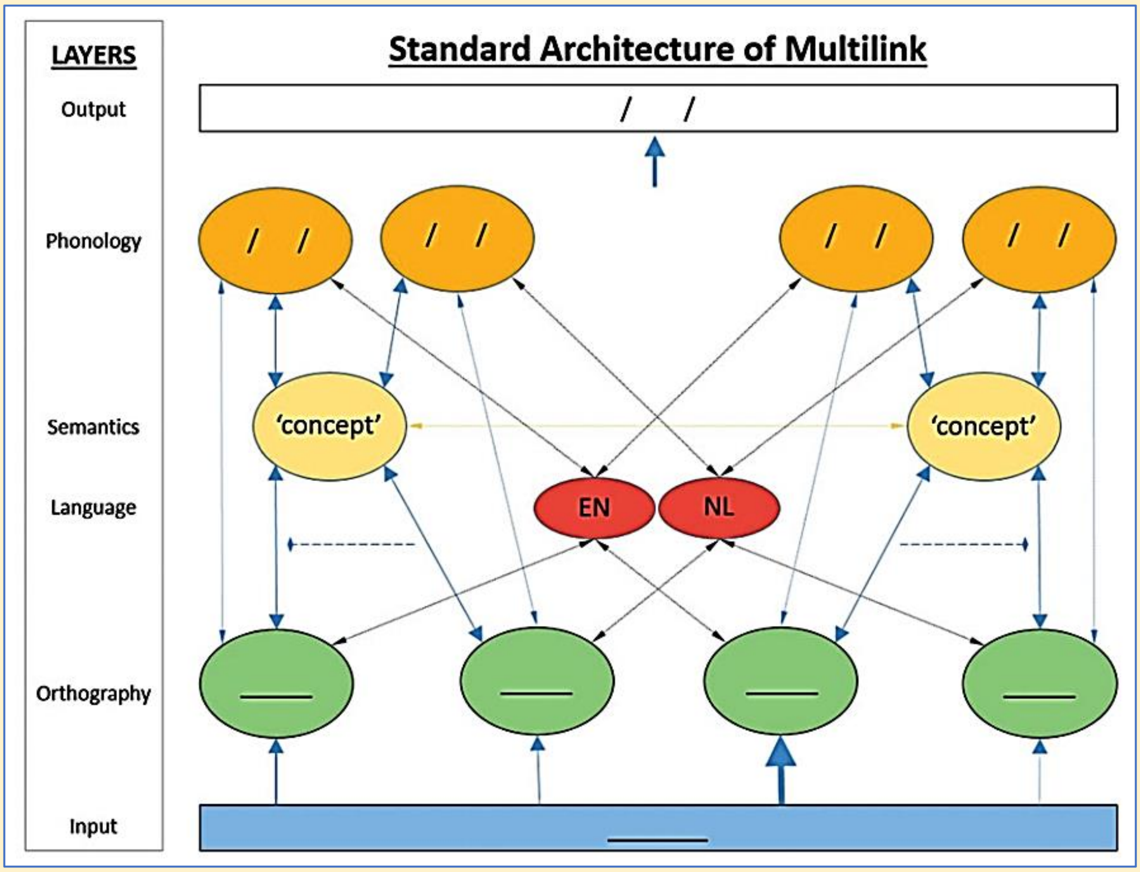

Figure 4. Standard network architecture of Multilink (from Dijkstra et al., 2019).

Therefore, even if the Multilink model is not a developmental model, it takes into consideration **the level of proficiency in L2**. More, it allows the simulation of cognate and non-cognate word processing. Actually, cognate words are a useful tool to study the links between phonological and orthographic representations of L2 words, given the orthographic without phonological sharing they represent. Therefore, the Multilink model is essential for this thesis project, aiming to analyse the impact of L2 word presentation modality on word recognition, and thus the links between both representations of L2 words, among late French-English bilinguals having learned English in an academic context, and thus from a large range of L2 proficiency.

1.2.4.2.Experimental validations of the Multilink model.

In 2019, Dijkstra and collaborators proposed the Multilink model, notably to take into account L2 proficiency during task completion, but also to account for cognate word processing and for different types of cognitive tasks. They performed five simulation studies to demonstrate the fact that their proposed model was applicable to various tasks and stimuli. The first one concerned English and Dutch lexical decision tasks, and demonstrated **high correlations between Multilink outputs and empirical behavioural data** (which consisted in the British Lexicon Project - Keuleers et al., 2012 - and the Dutch Lexicon Project - 6).

As Multilink combines different characteristics of previously mentioned models, their experimental validations could be applied to the Multilink model (Dijkstra et al., 2019). Furthermore, the specificities of cognate word representations were tested through bilingual lexical decision tasks in English with and without pure Dutch words. They demonstrated that **cross-linguistic overlap of cognate words**, and especially of identical cognate words, **helps their recognition in a pure L2 list, while it hampers it in a mixed L1-L2 list**. The same paradigm, combined with fMRI, was conducted in parallel, demonstrating a reverse pattern (Peeters et al., 2019). However, the huge differences highlighted between identical and non-identical cognate words was interpretated by the authors as a proof of the reliability of the Multilink framework as a word identification system.

To summarise, the BIA-d (Grainger et al., 2010) and much more the Multilink (Dijkstra et al., 2019) models are the most relevant models of bilingual word processing, considering the target population and the aims of this thesis project. Nevertheless, some other models have been described in the literature and help the understanding of word processing mechanisms.

1.2.5. Other models.

1.2.5.1. The Bilingual model of lexical access.

Given that the aim of this thesis project was to compare L2 written and spoken word recognition, and that most of the previous mentioned models were based on written word processing, the **BIlingual MOdel of Lexical Access** (BIMOLA – Grosjean, 1988, 1994; Léwy, 2015) could help the understanding of L2 spoken word processing. This model assumes the existence of **separate lexicons**, activated depending on the global language mode defined by the context. Phonemic features, phonemes and words are then activated through bottom-up and top-down connections. However, this model has been designed to describe L2 spoken word recognition among high proficiency bilinguals. More, it doesn't allow an interaction between modalities.

1.2.5.2. The Bilingual language interaction network for comprehension of speech.

The **Bilingual Language Interaction Network for Comprehension of Speech** allows this interaction between modalities (BLINCS – Shook & Marian, 2013). This latter model is structured into phonological, phono-lexical, ortho-lexical and semantic levels self-constructed by a self-adaptive algorithm. In each level, the representations of the two languages are in the same network, allowing a cross-language lexical competition. The ortho-lexical component of this model ensures interactions between phonological and orthographic forms during the recognition of spoken words. However, this model does not take into account L2 proficiency. Besides, it does not describe precisely the links between orthographic and phonological representations of L2 words.

1.2.6.Conclusion.

The different models of word recognition in bilingual contexts each have their own specificities, as described above, in particular concerning the population they refer to, or the type of task they are adapted to. Most of them indeed consider high proficiency only, whereas some take into consideration L2 proficiency, as is the case for the BIA-d and Multilink models (Dijkstra et al., 2019; Grainger et al., 2010). Those models seemed the most relevant for the current work, even if no existing model seems perfectly adapted. Moreover, some of those models have been specifically established to describe the recognition of written words, while others focus on the recognition of spoken words in L2.

Considering that the current project concerns late bilinguals, assumed to be unbalanced, and aims to compare word recognition across modalities, the Multilink model seems the most relevant model (Dijkstra et al., 2019). Indeed, the Multilink model presents some particularly relevant characteristics: the presence of a phonological component, the fact that L2 proficiency could be taken into consideration, and that the processing of cognate word recognition is also simulated – those translation equivalents sharing orthographic more than phonological forms being good candidates for cross-modal comparison. Note that the BIA-d model (Grainger et al., 2010) is also adapted to this work. Nevertheless, those models still exhibit some shortcomings, notably because they are not particularly adapted to not-advanced L2 learners, for whom orthography-to-phonology mappings are crucial.

The distinction according to the modality of word presentation in some bilingual models of word recognition tends to indicate the existence of L2 lexical representations dependent on the modality, even if empirical data do not provide formal evidence of this, as we will now show.

1.3. L2 word recognition in both modalities.

The majority of studies on L2 word recognition considering one modality only, we will distinguish experiments on the basis of the modality/modalities they refer to, starting with the written one.

1.3.1. L2 written word recognition: empirical data.

Written word recognition is commonly acknowledged as one of the lower-level cognitive processes involved in reading. Besides, it is admitted as the most “recurring cognitive activity” on which reading activity is based (Perfetti, 2007). This probably explains why L1 word recognition research abounds. Critically, L2 word recognition experiments were less spread in the scientific literature until the last three decades, probably in relation to its involvement of multiple languages, leading to more complicated issues.

Nevertheless, since the end of the 20th century, many studies have analysed the specificities of L2 written word recognition. Several main attentional foci were described in the field of L2 word recognition research, among which we will here focus on the most relevant one considering our global objectives (see for a systematic review: Han, 2015).

In 1998, Muljani et al. proposed an English (L2) lexical decision task to different groups of participants, varying in their L1. They involved Chinese, Indonesian and English native-speakers, respectively corresponding to L1 logographic bilingual readers, L1 alphabetic bilingual readers, and monolinguals. They demonstrated a main effect of **L1 background**, monolinguals performing the task faster than L1 alphabetic bilingual readers, themselves being faster than L1 logographic bilingual readers. We will not further detail this aspect, considering that our population of interest consists in French-English bilinguals, whose L1 background is similar (same alphabetic system).

We will focus more on behavioural studies of L2 written word recognition. For example, Van Heuven et al., in 1998 (see section 1.2.1.2 page 13 for the methodology used), highlighted a **lexicality effect**, with shorter response **latencies** for words than pseudowords. This lexicality effect was demonstrated among both monolingual and bilingual participants. More, even in a situation in which participants never used their L1, **L1 neighbourhood had inhibitory effects** on L2 word recognition, whereas **L2 neighbourhood had facilitatory effects** on it.

This experiment was congruent with that of Bijeljac-babic and collaborators (1997) who proposed English lexical decision tasks into a masked priming paradigm, among French-English high proficiency bilinguals. The masked primes were either L1 or L2 frequent written words, sharing or not some letters with the targets, each for a half, and thus called "orthographically related" and "unrelated" primes. They demonstrated that orthographically related primes had inhibitory effects on target recognition, and that L2 primes (*i.e.*, primes in the same language as the targets) had also inhibitory effects on target recognition, displayed by longer latencies. Those results were in line with the non-selective access hypothesis of bilingual models of word recognition mentioned previously. A further experiment replicated this **cross-language inhibitory orthographic priming**, demonstrating that this effect depends on L2 proficiency: the more proficient a participant, the larger the amplitude of the orthographic priming.

Additionally, in 2016, Oganian et al. (see section 1.2.1.2 page 13 for a description of the paradigm used) showed a similar **lexicality effect**, with shorter response latencies and **fewer errors** for words than pseudowords. Moreover, they highlighted: a) a **language effect**, with shorter response latencies and fewer errors in L1 than in L2; and b) a **length effect**: the shorter the word length, the shorter the latency.

Furthermore, a **frequency effect** was also found in L2 word recognition studies. For example, Diependaele et al. (2013) analysed the data from Lemhöfer et al. (2008) to analyse precisely word recognition latencies, relatively to lexical frequencies. They confirmed the frequency effect observed by Lemhöfer and colleagues, adding the importance of taking into account L2 proficiency when considering L2 word recognition. Indeed, the size of the lexical effect was shown to be dependent on vocabulary breadth.

Thus, several studies have shown the interactions between the well-known lexicality effect in L2 on the one hand and language, word length, or L1 and L2 neighbourhoods on the other hand. Besides, other parameters have to be taken into account during L2 written word recognition, such as cognateness. Indeed, there is a specific category of words, with very particular characteristics: the cognate words. Those words are translation equivalents of two languages whose orthographic forms are very close to each other (Schepens, 2012; Schepens et al., 2013). Those cross-language word similarities are especially interesting to understand word recognition processes, due to the challenge those form-similar words provide to the recognition system. That is why many studies have been conducted to highlight the **cognate facilitation effect** (even if some other studies showed that the presence of cognate words in a text would hamper the reading – A. K. Davis et al., 2018) through different paradigms (see notably for a review: Lauro & Schwartz, 2017).

For example, Dijkstra et al., in 1999, analysed accuracy and latencies of L2 written word recognition among 30 Dutch-English highly proficient bilinguals, including cognate words. They highlighted the cognate facilitation effect, with cognate words inducing shorter response latencies and fewer errors than non-cognate words. In the same vain, Lemhöfer and Dijkstra (2004) investigated the interaction between L2 written word recognition and cross-language overlap (semantic, orthographic and phonological) through four experiments, among Dutch-

English highly proficient bilinguals. They showed the same type of cognate facilitation effect, semantic and orthographic overlaps allowing shorter response latencies and fewer errors.

In 2010, Dijkstra et al. analysed more specifically the impact of cognate word characteristics on L2 word recognition. They distinguished **identical cognates** (with a complete orthographic overlap between translation equivalents – for example in English and French: *guide*) and **non-identical cognates** (with a partial orthographic overlap between translation equivalents – for example in English and French: *tomato / tomate*). Twenty-three Dutch-English highly proficient bilinguals performed an English lexical decision task. They were faster for identical cognates than non-identical ones, even if a cognate facilitation effect (of lower amplitude) is observed with a partial orthographic overlap.

Nevertheless, despite this large amount of work devoted to high proficiency bilingual word processing, less is known about intermediate proficiency L2 word processing, and even less about this processing among L2 learners who have been studying the L2 in an academic context. Note that, in 2005, Duyck proposed to 22 Dutch-English bilinguals, having learned English in an academic context and with intermediate proficiency in English, an English lexical decision task including **pseudo-homophones**, both in L1 and in L2. The author highlighted a priming effect with both pseudo-homophones in L2, suggesting a non-selective activation of phonological representations during L2 written word recognition.

Furthermore, Duyck et al. (2008) investigated the effect of **word frequencies** on word recognition, either in L1 and in L2, among low proficiency bilinguals. They observed both a language effect (faster responses and fewer errors in L1 than in L2) and a frequency effect (faster responses and fewer errors for high frequency words than low frequency ones, whatever the language, with a larger amplitude in L2).

In summary, L2 written word recognition has been extensively investigated, through various experimental paradigms and among bilingual populations of varying proficiency levels (although mostly among highly proficient bilinguals). It has been established that many parameters influence L2 written word recognition. Many studies have also investigated the interference of both languages during a monolingual task (see for a bilingual Stroop effect: Schmidt et al., 2018). However, even though the research on L2 word recognition mainly focused on the visual modality, bilinguals use L2 not only for reading but also for listening to speech. Thus, L2 mastery requires both written and spoken communication skills. That is why we will now focus on the specificities of L2 spoken word recognition, the main aim of this thesis project being the comparison of L2 word recognition in both modalities.

1.3.2. L2 spoken word recognition: empirical data.

Numerous studies have also investigated L2 spoken word recognition. Among these studies, some took into consideration **cross-language phonological similarities** – including interlingual homophones (*i.e.*, words of both L1 and L2 whose phonological forms are similar) – whose effect could be modulated by several parameters, as for written word recognition (Brysbaert et al., 1999; Dijkstra et al., 1999; Doctor & Klein, 1992; Gollan et al., 1997; Lam et al., 1991; Schulpen et al., 2003; Tzelgov et al., 1990, 1996; Veivo & Järvikivi, 2013).

For example, Schulpen and colleagues (2003) designed a cross-modal priming task with auditory primes (L1 control words or interlingual homophones) and visual targets (L2 words). Twenty-four highly proficient Dutch-English bilinguals were tested. Their results – longer reaction times for interlingual homophones than control words – suggested that interlingual homophones activate their meanings in both languages, consisting in an **online lexical competition** between both representations. Further investigations let authors to highlight the use of sub-lexical cues to differentiate those two versions after this language non-selective access.

In addition, Marian and colleagues conducted a series of experiments demonstrating evidence for a language non-selectivity during spoken word recognition (Marian et al., 2003, 2008; Marian & Spivey, 2003a, 2003b; Spivey & Marian, 1999). In 2003, they proposed to highly proficient late Russian-English bilinguals, who were living in an L2-dominant environment, eye-tracking studies. Their participants were instructed to pick up some real-life objects, through L2 spoken instructions. Their results were consistent with the **language non-selectivity** hypothesis, with fewer fixations on distractors with L1 name phonologically unrelated to the L2 target than on competitors with L1 name phonologically similar to the target, whereas instructions were provided in L2. They also demonstrated evidence in favour of the language non-selectivity in L1 (Marian & Spivey, 2003a; Spivey & Marian, 1999) with the same type of paradigm, except instructions provided in L1.

Thus, those spoken word recognition experiments are in line with an **integrated lexicon**, allowing cross-language competition. Moreover, this language non-selectivity seems to be dependent on the amount of language exposure (Spivey & Marian, 1999), the language proficiency (Marian & Spivey, 2003a, 2003b; Weber & Cutler, 2004), the age of L2 acquisition (Marian & Spivey, 2003b; Weber & Cutler, 2004) or the acoustic characteristics of the signal, such as the voice onset time (Ju & Luce, 2004). Those parameters are crucial for spoken word processing, due to the influence of the age of L2 acquisition and the amount of L2 exposure on the perception and the production of L2 phonemes (Flege et al., 1999; Piske et al., 1999).

Besides, as explained previously, cognate words are good tools to analyse the impact of the modality on word processing, due to their inherent characteristics (cross-language orthographic without phonological similarity). Indeed, cognate words are words whose translation equivalents are most often closer orthographically than phonologically (*e.g.*, ‘guide’ is written identically but pronounced differently in French and English – Schepens et al., 2013). That is probably why, even if many studies have been conducted during the last four decades to highlight the cognate facilitation effect during written word recognition (see section 1.3.1 page 25), this was only during the last 15 years that studies were conducted to analyse **cognate spoken word recognition.** And there are few relevant studies on this specific topic until the last decade (see notably: Blumenfeld & Marian, 2007; Freeman et al., 2016; Kelley & Kohnert, 2012; Marian et al., 2008; Wu et al., 2019).

In 2007, Blumenfeld and Marian compared the co-activation of German language during English spoken word recognition among three groups: English-German bilinguals, German-English bilinguals and English monolinguals. They included in their list of targets English-specific words and English-German cognate words. They highlighted that the co-activation of German language during English word recognition depends on German proficiency. Cognateness also seems to enhance the non-selective language activation among lower German proficiency participants. Indeed, German-English bilinguals co-activated German with all targets, while English-German bilinguals co-activated German with cognate targets only. The same type of **cross-linguistic phonological overlap effect** has been highlighted with other tasks (see for cross-modal phonological priming lexical decision task: Freeman et al., 2016; and for L2 word recognition in a sentence context: Lagrou et al., 2013) and language pairs (see for Russian-English: Marian et al., 2008 experiment 3; and for Spanish-English: Freeman et al., 2016).

L2 spoken word recognition has therefore been less investigated – compared to L2 written word recognition. Various experimental paradigms and bilingual populations of varying proficiency levels, notably highly proficient bilinguals (see for low to intermediate proficiency bilinguals performing translation task: Veivo et al., 2015) have been studied. It has been established that many parameters influence L2 spoken word recognition – as well as written one, and that cognate words are particularly relevant items to analyse them. However, L2 word recognition has mostly been studied with each modality being considered independently. The question of the impact of modality on L2 word recognition thus remains unanswered properly, as we will now illustrate.

1.3.3. L2 word recognition: impact of the modality?

Critically, because of their orthographic without phonological sharing between translation equivalents, cognate words seem to be relevant items to explore this issue. Indeed, in this section, we will present empirical data – including cognate and non-cognate items – concerning word recognition in both modalities in order to determine whether these data can provide some answers as to the existence of L2 lexical representations dependent or not on word presentation modality.

In order to further evidence the major interest of cognate words in the field of L2 word recognition across modalities, it is important to keep in mind that unbalanced bilinguals tend to activate both languages in parallel, even in a monolingual situation of spoken word recognition (Marian et al., 2003). To establish whether L1 and/or L2 conversion systems are activated during L2 written word recognition, Commissaire and colleagues (2019) proposed English lexical decision tasks to French adolescents during their first or third year of formal English learning. They included in their lists of stimuli pseudo-homophones that sounded like L2 real words both when using L1 and L2 OPM on the one hand, and pseudo-homophones that sounded like L1 real words when using L2 OPM on the other hand. They found **pseudo-homophone interferences** in all conditions, suggesting an automatic activation of both L1 and L2 OPM during L2 written word recognition among low proficiency bilinguals. Considering this co-activation of both conversion systems during L2 written word recognition, it is crucial to analyse what happens during L2 spoken word recognition, especially when cognate words are included into the lists of stimuli, because of their orthographic but not systematic phonological overlap between translation equivalents.

Moreover, the co-activation of both L1 and L2 during monolingual spoken word recognition among unbalanced bilinguals lead to expect an **interaction between modality and cognateness.** Very few studies analysed cognate word recognition in oral modality (see section 1.3.2 page 29), and there is no experiment directly comparing cognate word recognition between modalities.

Valente et al., in 2018, compared the impact of phonological and orthographic similarities of cognate words on the latencies of spoken cognate word recognition. They highlighted a **facilitation effect of the phonological overlap**, the orthographic one being controlled, which is congruent with the fact that even if orthographic, phonological and semantic codes are automatically co-activated during L2 word recognition, the temporality of their activation depends on the nature of the task (Dijkstra & van Heuven, 2002).

In summary, there is some evidence that bilinguals activate simultaneously L1 and L2 lexical representations, both in written and oral modalities, with some interactions between modalities, notably through OPM.

Nevertheless, there is, to our knowledge, only one study examining the **impact of modality in a situation of multilingual word processing**. Veivo and colleagues (2015) proposed an experiment to a group of Finnish learners of French, all bilingual speakers of Finnish and English, all expert-readers who have learned French as a third language (L3) at school. One week after an online auditory French lexical decision task, participants performed a translation task from the same stimuli, presented auditorily again. Two months after these auditory tasks, the same translation task was performed, with a visual presentation of the same stimuli. Given that the practicalities of L3 learning at school in Finland are similar than those of L2 learning at school in France (*i.e.,* limited exposure combined with a bias in exposure in favour to the written modality), they highlighted a **modality effect** in L3, with higher accuracy scores for written words than spoken ones. Moreover, there was an interaction between L3 proficiency and modality, the modality effect being even greater for the low proficiency participants. They replicated those results in another study without a delay between modalities, using a repeated paradigm with a counterbalanced order of modalities.

It is important to note that the translation task necessitated a semantic processing, which is of a higher level of complexity and therefore does not allow to clearly determine whether L2 lexical representations are modal-dependant or not. The question then emerges as to the degree to which the first stage of word processing, namely word recognition, is sensitive to modality among intermediate proficiency bilinguals (note that the Cognitive Theory of Multimedia Learning had already highlighted a modality effect in L2 word learning, in favour of the oral modality, this modality effect being different in concept of that mentioned concerning word recognition – Knoop-van Campen et al., 2019; Mayer, 2005). Moreover, it is essential to evaluate whether modality and cognate effects interact during L2 word recognition among this population of intermediate proficiency bilinguals, known to show a greater cognate effect in L2 (see for a meta-analytic review Lauro & Schwartz, 2017).

1.4. Conclusion.

In this chapter, we have detailed the main characteristics of bilingualism, and the key outstanding issues concerning L2 lexical representations, with reference to the main models of L2 word recognition. We have mentioned the expected existence of a modality effect in L2, considering the probable modal-dependant lexical representations in L2 given the psycholinguistic models. This modality effect was anticipated to be in favour of the written modality, due to the existence of cross-language similarities between languages sharing the same alphabetic system, as is the case between English and French. Moreover, the inherent practicalities of L2 learning in an academic context would enhance this bias in exposure to the written modality, which appears particularly not suitable for individuals with difficulties in written stimuli processing, such as dyslexic-readers. That is why it seemed important to us to take into consideration L1 reading efficiency during L2 word recognition, through a comparison of typical and dyslexic-readers. The next chapter will thus be devoted to an overview of this particular impairment.

Chapter 2. Word recognition in developmental dyslexia.

"Show me a family of readers, and I will show you the people who move the world."
Napoléon Bonaparte

"I don't 'suffer' from dyslexia, I live with it and work with it. I suffer from the ignorance of people who think they know what I can and cannot do."
Erica Cook

In France, 6 to 8% of children present a **developmental dyslexia** (DD – Barrouillet et al., 2007). Therefore, L2 learning in a school context takes place in classes with one or two dyslexic-readers in average, even though L1 reading skills influence L2 learning (see for the correlation between L1 reading scores and L2 proficiency: Salgado, 1990). That is why it seems crucial to take into account this reading impairment when studying the impact of modalities during L2 word recognition among the specific target population of this project. Because their L1 reading difficulties were demonstrated to be observed also in L2 (Lindgrén & Laine, 2011a; Palladino et al., 2013; van Setten et al., 2017), it is crucial to understand their difficulties in L1, before starting the evaluation of their difficulties in L2.

The next section will thus be devoted to a brief definition and characterization of this disorder. We will then provide an overview of their specific difficulties, with empirical data of written word recognition among dyslexic-readers. Finally, considering the characteristics of dyslexic individuals and the practicalities of L2 learning in an academic context in France, the question arises about the difficulties experienced during this learning in an academic context by dyslexic-readers.

2.1. Developmental dyslexia: a brief overview of its specificities.

2.1.1. Characteristics of developmental dyslexia.

A huge proportion of children presents persistent reading difficulties (Andreu et al., 2021, 2019). Several aetiologies[5] can be considered for these difficulties, among which some are **external** from the reader (Clay, 1987; Cole et al., 2020; Vellutino et al., 1996, 2004, 2006), and others are **internal explanations** of his/her reading difficulties, such as a sensory (visual or auditive) or neurological disorder for example (Cole et al., 2020; Lyon et al., 2003; Tunmer & Greaney, 2010; Vellutino et al., 2006). When all of these various possible aetiologies of reading difficulties have been ruled out, the question arises as to the existence of a written language developmental disorder, or developmental dyslexia (DD), which thus constitutes an **exclusion diagnosis.** Furthermore, even if those exclusionary criteria seem consensual, the terminology concerning this reading disorder was less so, until the CATALISE consortium[6] (Bishop et al., 2016, 2017). Several definitions of developmental dyslexia were thus proposed[7], depending on the classification notably used. Some criteria were however common and fundamental.

Therefore, in 2003, Lyon and collaborators stated that DD is a learning disability, from a neurobiological origin, characterized by a **non-fluent written word recognition**, with a significant number of errors, and by poor spelling and decoding abilities – dyslexia being defined on a *continuum* of word reading ability as the low end of a normal distribution (Peterson

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[5] In this manuscript, we will not discuss the aetiology of dyslexia, which is complex, multifactorial and still controversial (see for example Bishop, 2015). We have only included here the differential diagnoses of dyslexia for reading difficulties.

[6] See Appendix 1 page 278 for more details.

[7] We won't detail all of those definitions in this manuscript. See the DSM-V or CIM-11, for examples.

& Pennington, 2015; Rodgers, 1983; Shaywitz et al., 1992). They also specified the exclusionary criteria mentioned above, as differentiating conditions.

To further clarify the essential criteria of this definition of dyslexia, Tunmer and Greaney (2010) laid the foundation for a definition framework (see also: Catts & Kamhi, 2005). Therefore, DD was defined by: a) the **exclusionary criteria** mentioned above, allowing a precise diagnosis, and ensuring the quality of teaching and educational environment; b) the **persistence** of symptoms throughout the life; and c) the existence of a **phonological deficit**.

This definition is relatively consensual among researchers in the field of DD, despite some disagreement about the aetiology of the symptoms – not only based on a phonological deficit but which is more complex and multifactorial according to some authors (Cole et al., 2020). Indeed, four main hypotheses are currently suggested to explain the causes of dyslexia: phonological, auditory, visual and cerebellar hypotheses. We won't present these four hypotheses in detail in this manuscript (see for an investigation of those diverse hypotheses: Jones et al., 2013, 2016; Ramus et al., 2003; Saksida et al., 2016; White et al., 2006), but we will limit ourselves to the phonological one, as it is crucial for this thesis project purpose to analyse the links between phonological and orthographic lexical forms.

There are therefore controversies about what may cause DD (Cole et al., 2020). Nevertheless, Peterson and Pennington's review (2015) about DD highlighted the consensual notion than most of dyslexic-readers have phonological processing difficulties leading to written language processing disabilities. The **phonological hypothesis** was first identified by Snowling in 1981, by the less accuracy of word reading for the most phonologically complex words. It was also supported by Norton and colleagues (2015) for whom DD could be due to phonological awareness weaknesses. This phonological hypothesis assumes a deficit in the construction of phonological representations of words (Law et al., 2017; Ramus, 2010), which would hamper the development of decoding skills of dyslexic-readers – those skills depending on the quality of phonological representations – through the poor quality of their grapheme-phoneme correspondences learning (Ziegler & Goswami, 2006). In 2008, Ramus and Szenkovits precise those assumptions, through the phonological triad. Thus, DD is characterized by a deficit in the three main predictor of reading efficiency, that are phonological awareness, verbal short-term memory and rapid automatized naming. This phonological deficit is responsible for the difficulties of dyslexic-readers to access the phonological form of written stimuli.

Therefore, dyslexic-readers are characterized by a phonological deficit, which is responsible for their reading difficulties, according to the dual-route cascaded (DRC[8]) model of "visual word recognition and reading aloud" (Coltheart et al., 2001) we will now introduce.

2.1.2. The DRC model and developmental dyslexia.

This model was designed at the beginning of the 21st century to account for the altered processing of reading in dyslexic-readers, compared to expert-readers. This model hypothesized two possible pathways for written word recognition: the phonological and the lexical pathways (see Figure 5 page 40).

The basis of the **phonological pathway** consisted in grapheme-phoneme conversion rules (GPC rules). Through this route, readers performed a sequential decoding of written information using GPC rules. At the beginning of learning to read, or when expert-readers are reading pseudowords or words they have never encountered before, this route allows the recognition of written words. The rapidness of acquisition of decoding depends on the consistency of the orthography of the language considered: the less consistent is the

[8] We won't give here an exhaustive review of all the models of L1 word recognition (for more details, see Norris, 2013). We want just to provide the theoretical tools crucial for understanding our work, which only corresponds to the DRC model.

orthography, the more difficult is the decoding of new word and/or pseudoword, GPC rules being less systematic.

In addition, the **lexical pathway** is based on a direct access to the orthographic form of familiar words, already integrated in the mental lexicon of the reader. Secondarily, the activated orthographic form activates the associated phonological form of each word. It therefore allows for the quick reading of familiar words, already integrated in the reader's mental lexicon. Concerning expert-readers, most words, especially frequent ones, are recognized by this procedure.

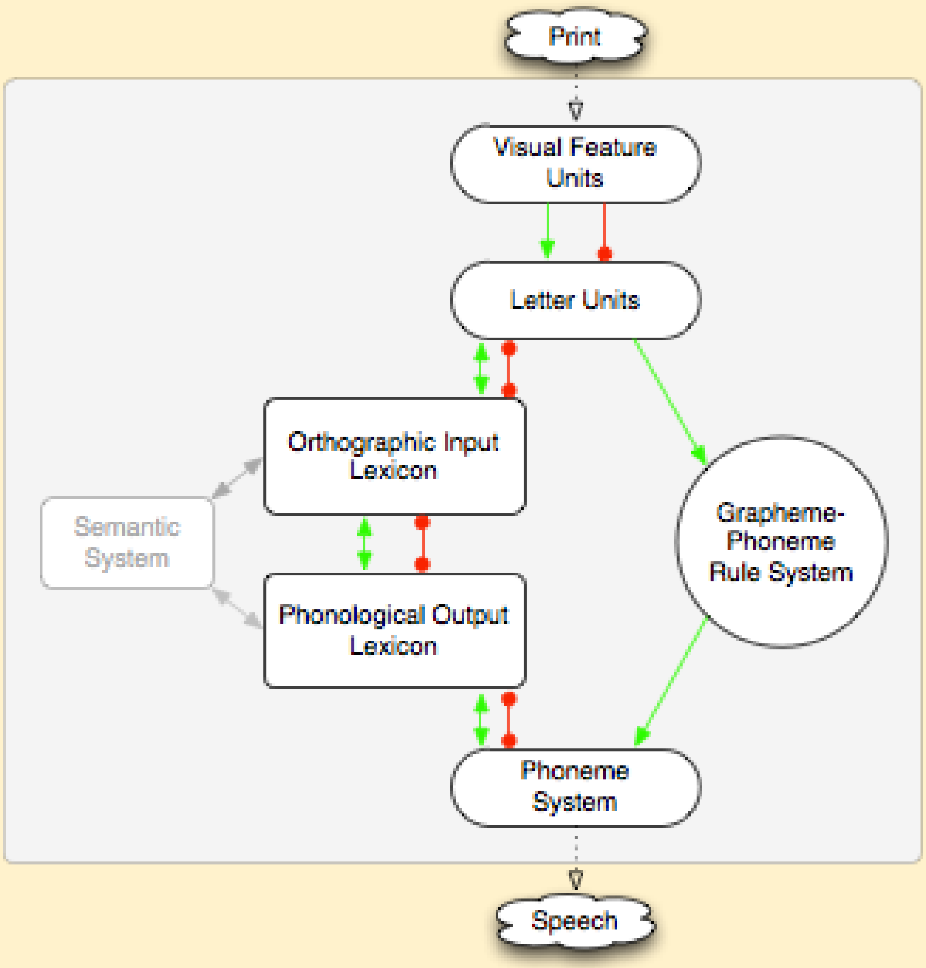


Figure 5. The dual-route cascaded model of visual word recognition and reading aloud (from maxcoltheart.wordpress.com; Coltheart et al., 2001).

Green arrows correspond to excitatory connections, red ball-headed ones are inhibitory connections, grey arrows represent the lexical semantic route, not implemented.

The DRC model (Coltheart et al., 2001) accounts for a huge number of experimental results on word recognition. Notably, there are a large number of studies on dyslexic-reader difficulties, which demonstrate the existence of those complementary pathways of written word recognition.

Indeed, the dominant explanatory hypothesis for reading difficulties in DD is a phonological deficit with, among otherwise, an alteration in the ability to access phonological representations from written words (Law et al., 2017; Norton et al., 2015; Peterson & Pennington, 2015; Ramus, 2010; Ramus & Szenkovits, 2008; Snowling, 1981; Ziegler & Goswami, 2006). This deficit would impair reading *via* the phonological pathway during the learning of reading, and would then compromise the establishment of the lexical pathway (Coltheart et al., 2001; Gangl et al., 2017). However, the deficits in these procedures can be more or less noticeable, thus reflecting a certain heterogeneity in dyslexia. Therefore, different profiles of dyslexic-readers have been highlighted depending on the procedure or procedures altered, which correspond to the pathway or pathways altered in the DRC model (Coltheart et al., 2001).

Actually, given that the phonological pathway is based on a sequential decoding of words, it takes more time than the lexical pathway. Therefore, to test the sub-lexical procedure, researchers often used tasks such as reading aloud words and pseudowords. Pseudowords not being part of the mental lexicon, they forced decoding through the phonological route. This assumption of the DRC model (Coltheart et al., 2001) accounts for the **lexicality effect** (Balota, 1994; Balota et al., 2004; Balota & al, 2006) highlighted on word recognition, with a faster recognition of words (read through the lexical procedure) compared to pseudowords (read through the sub-lexical procedure). An alteration of the phonological pathway thus results in an inability to learn correctly GPC rules, and thus to a particular difficulty to read pseudowords or words never encountered before, whereas familiar words could be read through the lexical pathway (Campbell & Butterworth, 1985; Hulme & Snowling, 1992; Seymour & Macgregor, 1984; Stothard et al., 1996; Temple, 1985; Temple & Marshall, 1983; Valdois et al., 2003).

Conversely, an alteration of the lexical pathway results in an incapacity to memorise the orthographic form associated with a word, and thus to an important difficulty to read familiar words (Castles et al., 1996; Hanley et al., 1992; Temple, 1984a, 1984b; Valdois et al., 2003). Moreover, considering that language orthography is somewhat inconsistent, some words are more difficult to read through the phonological pathway, those words needing to use non-systematic GPC rules. Those words were called "irregular words[9]", while the "**regularity effect**" was taken as an indicator of the reliance on the sub-lexical procedure for word reading, whereas familiar words assumed to be read through the lexical route should not depend on sub-lexical factors such as consistency (Balota & al, 2006).

The **length** of items (words and pseudowords) was also a sub-lexical factor reflecting the use of the phonological route (Brysbaert et al., 2016; Ferrand et al., 2010; Keuleers et al., 2010, 2012; New et al., 2006): the longer a word is read through the phonological route, the longer is its latency of reading, because of the associated sequential decoding.

Finally, lexical frequencies were demonstrated to be the most relevant predictor of lexical decision latencies (Cortese & Khanna, 2007). The **frequency effect** accounts for the fact that familiar words are read through the lexical route, faster than the phonological one (see also: Brysbaert et al., 2016; Ferrand et al., 2010; Keuleers et al., 2012).

Therefore, this model helps the understanding of dyslexic-reader difficulties. Considering the critical role of the phonological code in lexical access during visual word recognition on the one hand, and the phonological deficit of dyslexic-readers on the other hand,

[9] Note that we prefer the term "inconsistent words".

the question then arises as to the efficacy of written word recognition processes among dyslexic-readers. The next section will therefore provide a brief overview of empirical data concerning written word recognition among dyslexic-readers.

2.2. Written word recognition among dyslexic-readers: empirical data.

Confronted with a written word, the visual information into one's attentional focus initiates the further processing of its associated elements – *i.e.*, orthographic, phonological and semantic information (Grainger, 2008). Many studies have analysed the specificities of written word recognition (see for a review: Fu et al., 2020) from a large spectrum of: a) perspectives (*e.g.*, behavioural, clinical, neuropsychological, *etc*); b) methods (*e.g.*, computational models, structural neuroimaging, functional neuroimaging, *etc*); c) paradigms (*e.g.*, semantic categorization, word naming, priming, lexical decision, *etc*); d) languages (*e.g.*, English, French, Dutch, German, etc); and e) target populations (*e.g.*, expert and dyslexic-readers).

The impact of written language processing difficulties has therefore been well examined, through single-case and group studies (Campbell & Butterworth, 1985; Hanley et al., 1992; Hanley & Gard, 1995; Hulme & Snowling, 1992; Rack et al., 1992; Seymour & Macgregor, 1984; Stothard et al., 1996; Temple, 1984a, 1984b, 1985; Temple & Marshall, 1983; Valdois et al., 2003). We will focus only on group studies, more adapted to the current project.

Dyslexic-readers have been characterised by **difficulties in pseudoword decoding and non-word repetition**, reflecting the impairment of the phonological pathway (Snowling, 1981; see also for a review: Rack et al., 1992). Furthermore, written word recognition was fully investigated among dyslexic-readers, demonstrating the specific impairment they present and the **persistence of those difficulties** in adulthood.

For example, Bruck (1990) reviewed and compared different studies on word recognition among typical and dyslexic-readers. In addition, in her study, Bruck compared dyslexic-reader performances on reading tasks with those of chronological and reading age-matched typical-readers. Her findings and the studies reviewed demonstrated that dyslexic-readers are characterized by **a slower and less accurate written word recognition** than typical-readers. Furthermore, they use written word recognition processes that correspond to **immature processes**, commonly used by younger typical-readers, such as orthography-to-phonology mappings, while their grapheme-phoneme correspondences knowledge is incomplete.

In addition, in 2014, de Oliveira and colleagues compared a group of 18 dyslexic children with a group of 22 typical-readers, all from grades 2 to 8. Both groups were assessed on several tasks, implying various skills. They demonstrated the **impairment of written word recognition among dyslexic-readers**, which is congruent with other studies.

Critically, the most relevant parameters concerning written word recognition among dyslexic-readers are **lexicality, frequency and consistency** (Campbell & Butterworth, 1985; Castles et al., 1996; Hanley et al., 1992; Hulme & Snowling, 1992; Seymour & Macgregor, 1984; Stothard et al., 1996; Temple, 1984a, 1984b, 1985; Temple & Marshall, 1983; Valdois et al., 2003). Those parameters were congruent with the various assumptions of the DRC model (Coltheart et al., 2001). Actually, those parameters impact written word recognition, because of the difference in processing through both pathways. Words, when familiar, are recognized through the lexical pathway, and thus are faster and more accurately recognized than pseudowords, read through the phonological pathway. Familiar, and thus frequent words, are also faster and more accurately recognized than rare words, because of the pathway used for their recognition. Finally, the more consistent a word is, the more systematic the GPC rules apply, and thus the easier and faster its recognition is.

Considering the characteristics of dyslexic individuals and the practicalities of L2 learning in an academic context in France, the question now arises about the difficulties experienced during this learning in an academic context by dyslexic-readers.

2.3. Developmental dyslexia and late bilingualism.

2.3.1. Late bilingual dyslexic-readers: a research field still undeveloped.

Even if a huge number of studies have been carried out to analyse the impact and the consequences of bilingualism, only a few studies have focused on English as a foreign language (EFL) learning, defined by Łockiewicz and colleagues (2020) as the learning of English by students living in an L1-based environment and characterized by an English exposure mainly limited to schooling. Nevertheless, the few studies focusing on this topic demonstrated a predictability of EFL word reading given: a) L1 phonological awareness in Norwegian (Helland & Morken, 2016) and Chinese (Pan et al., 2011); and b) L1 rapid automatized naming in Dutch (Morfidi et al., 2007) and Chinese (Pan et al., 2011). More, in Finnish, L1 phonological short-term memory was highlighted as a predictor of EFL vocabulary learning (Service, 1992).

Therefore, phonological awareness, rapid automatized naming and verbal short-term memory influence word and pseudoword decoding and word recognition both in L1 and in L2 (Łockiewicz et al., 2020). However, DD is characterized by a deficit in these phonological processing skills, as mentioned previously. Given the linguistic interdependence (L1 skills influencing L2 skills – Cummins, 1979) mostly regarding orthographic and phonological skills (R. Sparks et al., 2006), those deficits would impair both L1 and L2 word recognition and decoding (Łockiewicz et al., 2020). That is why the same pattern of difficulties in word recognition or word and pseudoword reading was observed among dyslexic-readers in L1 (Lyon et al., 2003) and in L2 (Helland & Kaasa, 2005; Lindgrén & Laine, 2011a; Palladino et al., 2013; van Setten et al., 2017). However, most of studies dealing with DD and bilingualism analysed the effect of orthographic consistency, more than bilingualism *per se*.

Łockiewicz and colleagues (2020) studied the relationship between Polish and EFL learning difficulties among 16 Polish dyslexic-reader students compared with 16 Polish expert-reader students on the one hand, and among 16 English dyslexic-reader students compared with 16 English expert-reader students on the other hand. They demonstrated that the accuracy and fluency of word recognition and word/pseudoword reading depend on the inconsistency of Polish and English language orthographies (different GPC rules between languages), as well as of reading level. This is consistent with other studies demonstrating that L1 difficulties were also found in L2 (Everatt et al., 2000; Fazio et al., 2021; Ho & Fong, 2005; Lallier et al., 2014; Palladino et al., 2013; Sotiropoulos & Hanley, 2017), even if some studies showed cases of monolingual dyslexia (probably linked with the type of script of L1 – Wydell & Butterworth, 1999).

Nevertheless, further research is needed to explore the field of late bilingual dyslexic-readers confronted with word recognition, in order to determine: a) if the modality of word presentation has an influence on their speed and/or accuracy; b) whether their difficulties in written language processing hamper their learning of foreign languages; and c) if dyslexic and typical-readers are equal faced to L2 learning in an academic context, despite the specific difficulties presented by dyslexic-readers.

In order to address these various issues, it is necessary to determine a common baseline for L2 word recognition among both dyslexic and typical-readers. The question thus arises as to the possibility to apply expert-reader model of L2 word recognition to dyslexic-readers.

However, before discussing this, it is important to detail the characteristics of the target population of the current project, which will be the focus of the next part.

2.3.2.Characteristics of the target population.

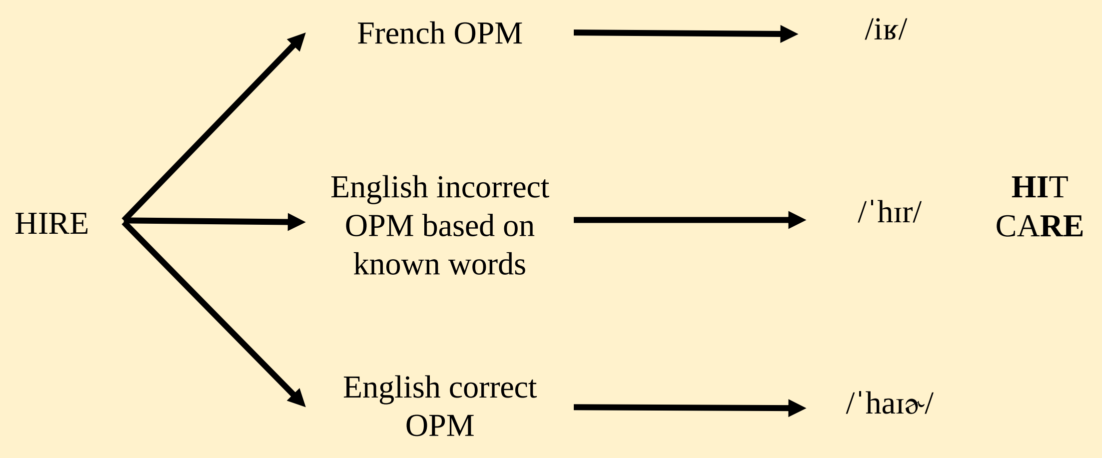
The population of interest consisted in typical and dyslexic-reader participants with the following characteristics: a) **late French-English bilinguals,** having mostly learned English in adolescence, thus in middle-school; b) **additive bilinguals**, both languages being particularly socially valued; c) **unbalanced bilinguals**, academic learning rarely resulting in balanced bilingualism; and d) **learned bilinguals**, with the L2 being an intrinsic part of formal school didactic situations. In addition, we will focus on L2 word recognition across modalities.

As mentioned in the BIA-d model notably (Grainger et al., 2010), the development of language skills is fundamentally different during L2 learning and L1 acquisition. Actually, the mastery of a language requires both oral and written communication skills, including phonological, lexical, morpho-syntactic, spelling, reading and comprehension skills. In addition, late L2 learners are individuals who learn an L2 after the completion of L1 acquisition. Thus, their main characteristic is **literacy**: they know how to read in their L1 before starting L2 learning. This characteristic explains, on the one hand, the influence of L1 reading skills in the L2 proficiency acquired during this learning and, on the other hand, the predominance of written materials during L2 learning in an academic context.

Thus, firstly, **their L1 reading skills influence their L2 learning**. For example, Dufva and Voeten, in 1999, demonstrated among 160 Finnish school children that L1 literacy skills in grade 1 are one of the most crucial factors of L2 proficiency in grade 3 (see for the correlation between L1 reading scores and L2 proficiency: Salgado, 1990). Furthermore, L1 orthography influences L2 word recognition, as highlighted by Commissaire and collaborators (2019) through pseudo-homophone interferences suggesting an activation of L1 orthography during L2 written word recognition among low proficiency late L2 learners. The possibility to apply the models to dyslexic-readers is therefore crucial.

Secondly, because late L2 learners know how to read in their L1, L2 lexical learning is mediated not only by spoken interactions with peers and teachers, but also by written materials, which then become considerably valued. Moreover, the practicalities of L2 learning in an academic context tend to enhance the importance of the written modality during this learning, consisting in a bias in exposure in favour of the written modality, even if a sporadic L2 exposure could be modulated by the oral modality, *via* medias notably. Therefore, L2 learners have **less auditory than visual inputs in L2**, and thus less opportunity to create precise phonological representations of L2 words. Consequently, they often need to use orthography-to-phonology mappings (OPM) to decode L2 written words they encounter, because of their limited access to the phonological form of those words. In addition, this bias in exposure questions the robustness of the links between both orthographic and phonological representations of those L2 words. Nevertheless, dyslexic-readers difficulties concern the phonological pathway, and thus could impact their L2 word recognition and the robustness of those representations.

In addition, this use of OPM to decode L2 written words could be particularly difficult for late L2 learners. This is true, among many others, when the L2 is English, because of the **inconsistent orthography** of this language. The latter may cause L2 learners to be uncertain of the correct mappings between orthography and phonology (Ziegler & Goswami, 2005), mainly when their L1 present a less opaque orthography, as is the case for French language (Seymour et al., 2003). Moreover, French and English languages share the same alphabetic system, having the same letters, while their grapheme-phoneme correspondences (GPC) are distinct. Indeed, their phonetic features slightly differ (Ryalls et al., 1995). Among French phonemes, only some are also found in English, and 14 phonemes are specific to the English language. Thus, **those two languages have incongruent OPM** (*i.e.*, there are both phonemes and graphemes specific of each language, as well as common graphemes corresponding to different phonemes in both languages), as is the case between almost all language pairs. This inconsistency of the English language orthography and the incongruence between English and French OPM explain the particular difficulties of French late learners of English as an L2 to be certain of the correct OPM to use when confronted with L2 unknown written words (see Figure 6 below for an example of these particular difficulties), which is even more the case for dyslexic-readers.



<u>Figure 6. Example of the difficulties of French late learners of English as an L2 to be certain of the correct orthography-to-phonology mappings (OPM) to use when confronted with an L2 unknown written word.</u>

Here, we have taken the example of a relatively known English word (Hire) in order to facilitate the understanding of these different possibilities. This word is there considered as an L2 unknown written word. Confronted with this L2 unknown written word, French late learners of English as an L2 have different possibilities to decode them:

a) They can use French OPM to create a phonological representation (top arrow), but these OPM are unlikely to create the right phonological representation, given the incongruence of these OPM between the two languages; in this example, this would lead to the activation of the phonological representation of a French word, different from the L2 unknown written word.

b) They can also use the English OPM that they know. Unfortunately, the opacity of the spelling of English and the inconsistency of these OPM means that they do not necessarily know all of them, and that, even if they do know them, they may be mistaken in their choice of OPM to apply. Thus, with a little luck, they will be able to apply the correct OPM and form an adequate phonological representation (bottom arrow). They can also use wrong rules, for example based on known words, such as Hit and Care, and thus construct an incorrect phonological representation (medium arrow).

Those different possibilities explain the difficulties of late L2 learners, and even more when they are dyslexic-readers, to recognize L2 words.

Finally, late L2 learning is specific in that it requires the learning of lexical forms corresponding to concepts already associated with lexical forms in L1, as explicitly mentioned in the RHM (Kroll & Stewart, 1994; see also: Boddaert, 2019). Indeed, the learning of an L2 after the acquisition of the L1, especially in late adolescence or adulthood, implies that most of the concepts are already known and have already been associated with the corresponding lexical forms of the L1. However, lexical knowledge is essential for comprehension, both in written (Lervag & Aukrust, 2010; Nation, 2006) and oral (Nation, 2006; Noreillie et al., 2018; Staehr, 2009) forms. L2 learning is therefore characterized by **explicit lexical learning**[10], which is necessary for the development of comprehension skills, lexical skills being one of the fundamental predictors of L2 comprehension skills (Lervag & Aukrust, 2010). Thus, L2 lexical learning consists in creating new associations, in order to link L2 lexical forms with concepts already present in the L1 mental lexicon (see notably: Boddaert et al., 2021).

The population of interest being now characterized, we can discuss the possibility of application of expert-reader models of L2 word recognition to dyslexic-readers.

2.3.3. Expert-reader model application to dyslexic-readers: reality or utopia?

In this part, we won't deal with all the bilingual models of word recognition we have described beforehand. We will only focus on the BIA-d and the Multilink models (Dijkstra et al., 2019; Grainger et al., 2010). Indeed, those two models are particularly relevant for the current project, given the population it refers to and its main objectives.

[10] Even if an implicit vocabulary learning was observed through a brief exposure to spoken L2 words associated with their corresponding pictures in a set of studies (Bisson et al., 2013, 2015). However, this observation followed an experimental paradigm in laboratory, which environment completely differ from daily L2 exposure. This question needs to be further explored, which is not the focus of this work.

Thus, even if the BIA-d model was designed in reference to the written modality, this model could also be applied to the oral modality, according to its authors themselves (Grainger et al., 2010). This is crucial for this thesis project, aiming to analyse the impact of L2 word presentation modality on word recognition. Nevertheless, the authors never determined if this model can be applied to dyslexic-readers. Indeed, the BIA-d model is a developmental version of the BIA model (Dijkstra, Van Heuven, et al., 1998; Grainger & Dijkstra, 1992; van Heuven et al., 1998), in which the principle of a non-selective access was implemented. This principle allows cross-language interferences (Grainger et al., 2010). Thus, when L1 orthographic lexical representations are imprecise, combined with a phonological deficit, such among dyslexic-readers, cross-language interferences would be affected. That is why it is so important to take into consideration L1 reading efficiency when studying L2 word recognition in both modalities.

The Multilink model (Dijkstra et al., 2019), by the way, is a computational model allowing the simulation of word processing in monolingual or bilingual manners, including cognate words which are particular good items to investigate the impact of modality on word recognition. However, even if this model allows to take into consideration L2 proficiency, it is unclear how this model could simulate word recognition regards to L1 reading efficiency.

Finally, some studies demonstrated that L1 reading difficulties were also observed in L2 (Lindgrén & Laine, 2011a; Palladino et al., 2013; van Setten et al., 2017). Therefore, the existing bilingual models of word recognition among expert-readers are unlikely to be applied among dyslexic-readers, whose difficulties in written stimuli processing would interfere with L2 word recognition. Therefore, no existing model of L2 word recognition seems to be directly applicable to dyslexic-readers, needing further investigation to be adapted.

2.4. Conclusion.

In this chapter devoted to developmental dyslexia and word recognition, we have detailed the main characteristics of this reading impairment, according to empirical data confronted with the main written word recognition model among expert-readers, namely the DRC model (Coltheart et al., 2001). Considering the difficulties experienced during L2 word recognition by dyslexic-readers who have learned the L2 in an academic context, we provided an overview of the literature regarding this particular issue. Critically, it is important to keep in mind that this research field is still underdeveloped, probably partially as a consequence of a lack in scientific knowledge concerning the applicability of expert-reader models to dyslexic-readers. Indeed, it is particularly difficult to discuss some results without a model of reference. However, to be able to build this type of model, it is necessary to develop some research aiming to determine how dyslexic-readers deal with bilingual lexical processing, with regard to expert-readers. More specifically, it is crucial to understand how dyslexic and expert-readers performed word recognition, in both modalities (visual and auditory) and in both languages (L1 and L2), in order to identify their commonalities and differences concerning this particular processing.

In the hope of bridging this gap between current knowledge and the knowledge needed to develop such a model, the present thesis work was developed to address three main research questions, which will be detailed, as well as our assumptions, in the next section.

Research questions and hypotheses

The aim of this thesis project was to study English word recognition among typical and dyslexic-readers, involving both middle-school (adolescents) and university students (adults) whose L1 is French and having learned English as an L2 in an academic context (late bilinguals). For this purpose, we designed three experimental protocols (for five experiments) to explore the following research questions.

Question 1: To what extent are orthographic and phonological lexical representations equally available (Chapters 5 and 6)?

This first research question therefore concerned the impact of modality on word recognition accuracy, which reflects the availability of each representation. Thus, we wanted to study the impact of modality on L2 word recognition among typical-readers (adolescents and adults). In addition, we wanted to control these effects in L1 among the same participants, comparing both English and French languages as L1 and L2 (*i.e.,* by comparing French-English and English-French late bilinguals). Finally, dyslexic-readers presenting a phonological deficit, leading to written stimuli processing difficulties, we compared dyslexic and typical-readers to determine if they displayed the same type of modality effect, in L1 and in L2, or if dyslexic-reader difficulties impact this effect.

For these purposes, we designed an experimental protocol, in order to analyse the modality effect on word recognition accuracy (Chapters 5 and 6, respectively for L2 and L1), among the different groups of participants mentioned above. We expected to highlight the existence of:

a) **a modality effect on L2 word recognition**, with a more accurate recognition of written words than spoken ones, **among typical-reader middle-schoolers and university students,** this effect of modality being expected **whatever the language at stake,** given the incongruence between English and French orthographies making it more difficult L2 spoken word recognition and given the similar practicalities of L2 learning in an academic context in both countries responsible for a bias in exposure in favour of the written modality (we also considered a control in L1 where no specific impact was expected);
b) **no modality effect on L2 word recognition among dyslexic-readers**, given their difficulties in written stimuli processing on the one hand, and their inability to correctly learn orthography-to-phonology mappings which would also impair their L2 spoken word recognition, due to the inconsistency of English orthography and the incongruence between French and English orthographies.
c) a **modality effect on L1 word recognition among dyslexic-readers**, in favour of the oral modality, due to their difficulties to process written information.

Question 2: Does the presence of cognate items impact similarly L2 word recognition in both modalities (Chapter 5)?

This second research question therefore dealt with a direct comparison of cognate word recognition in both modalities. Actually, as previously mentioned, cognate words are particularly adapted items to analyse the modality effect on word processing, due to their characteristics. Indeed, cognate words are translation equivalents close orthographically more than phonologically (*e.g.,* 'guide' is written identically but pronounced differently in French and English – Schepens et al., 2013). In addition, because the specific population of unbalanced bilinguals is known to show a greater cognate effect in L2 (see for a meta-analytic review: Lauro & Schwartz, 2017), we wished to evaluate whether modality and cognate effects interact during L2 word recognition among the population of late bilinguals, assumed to be unbalanced. Finally, we wanted to control these effects among the same group of participants as for the previous question, comparing both English and French languages as an L2, as well as dyslexic and typical-readers.

For those purposes, the first experimental protocol was declined with and without cognate words (Chapter 5, respectively for L2), among the different groups of participants mentioned above. We anticipated:

a) an **interaction between modality and cognateness among typical-readers**, with a cognate facilitation effect in written modality, and no cognate effect, or even an inhibitory effect, in oral modality, due to the orthographic without phonological overlap between those translation equivalents;
b) **dyslexic-readers to be more sensitive to cognateness in written modality**, because those "L1-like" written words would activate orthographic representations they had already well inscribed into their mental lexicon.

Question 3: How robust are the links between orthographic and phonological lexical representations (Chapters 5 to 9)?

This third research question concerned both the availability and the level of activation of each representation, following word recognition in one modality. Indeed, many studies have demonstrated that orthographic and phonological informations interact with each other during isolated word recognition, in L1 as in L2 (*e.g.,* Holcomb et al., 2005; Seidenberg & Tanenhaus, 1979). We therefore wanted to determine if late bilinguals could benefit from the pre-activation of the lexical representation of a word in one modality when recognizing the same word in the other modality, both in L1 (Chapters 6 and 8) and in L2 (Chapters 5 and 7 at the list level, Chapter 9 at the item level).

For these purposes, we designed three experimental protocols, in order to study the impact of cross-modal repetition on word recognition. In addition, we wanted to control these effects among the same participants as previously, comparing both English and French languages as L1 and L2, as well as dyslexic and typical-readers. We expected to highlight:

a) a **more accurate and faster L2 spoken** word recognition among typical-readers, when the words were presented in **written form beforehand**;
b) a **greater benefit** from the princeps presentation of written words **for university students, compared with middle-school students**, linked with an increase in L2 proficiency;
c) an **analogous benefit** from the princeps presentation of written words **in L2 English than in L2 French**, those two languages being relatively similar in features (*i.e.*, concerning the opacity of their orthographies notably – Seymour et al., 2003) and given the fact that the academic context of L2 learning is relatively similar in France and in Scotland;
d) **no benefit** from the princeps presentation of written words, among **dyslexic-readers**, given their difficulties in written stimuli processing, highlighted through an interaction between group and order of presentation of modalities.

EXPERIMENTAL SECTION

Chapter 3. Experimental foreword

To initiate the experimental section, it is essential to deal with ethical considerations. The whole project was submitted to the Lille University Ethics Committee and to the National Commission for Information Technology and Civil Liberties (CNIL), which approved it. We also submitted the project to the Dundee University School Research Ethics Committee, for data collection during a 2-month Indoc internship at the School of Social Sciences of Dundee University, Scotland, United Kingdom, under the supervision of Dr Lynne Duncan. This committee approved it. All participants (and their parents for minor participants) of our experimental protocols gave their written informed consent.

The second essential point to keep in mind about this project is that it was carried out under particular conditions, notably during the years 2020 and 2021. Indeed, the health crisis linked to the COVID-19 pandemic made it impossible to recruit middle-school students during this period (French schools being closed during the lockdown, and they no longer accepted outside contributors when they reopened at the beginning of the September school year). Moreover, since Universities had also closed their doors, the recruitment of adults for experimental face-to-face sessions was also impossible. This had a significant impact on the recruitment of participants and in particular reduced our ability to recruit dyslexic individuals for our studies. Despite all these difficulties, and although the numbers of participants were lower than our ambitions for the groups of middle-school children and dyslexic individuals, we were able to carry out some of the planned studies, in particular thanks to the digital version of the latest experiments on the Psytoolkit platform (Stoet, 2010, 2017).

It is also necessary to set the bases of certain requirements for the experimental protocols and to detail the framework chosen for data analysis for each of the six experiments. We will start with a presentation of the draft database used for the selection of materials for each of these protocols.

3.1. Database of lexical frequencies in English textbooks used in French middle schools – linked with the APPREL2 ANR Project.

In order to explore the different research questions, we had to design several experimental protocols for which we needed to select English words according to a specific list of parameters. The various accessible databases (*e.g.*, SUBTLEX-UK – Van Heuven et al., 2014 – or CELEX – Van Der Wouden, 1990) contain all target parameters but with values corresponding to English native-speakers. Since our target population is French people who have learned English as L2 in a school context in France, the values contained in these databases, especially for written frequencies, did not seem relevant to us. It therefore seemed necessary to use a specific database, containing in particular the written lexical frequencies of the words encountered by French students during their school learning of English, and therefore particularly those seen in the English textbooks used in middle school in France.

The creation of such a database is a huge project included in one of the tasks of the APPREL2 ANR project (grant from the National Research Agency 16-CE28-0009-01), which aims to investigate the learning and development of the L2 lexicon in a school context. As this database did not yet exist at the beginning of this thesis work, the first months were devoted to the elaboration of a draft of this database, in the side-lines of the ANR project, listing all the words present in 32 textbooks distributed among the four middle-school grades (*i.e.*, grades 6 to 9) and coming from different publishers.

To develop this draft database, the 32 textbooks previously mentioned were scanned and transformed into text files, using an optical character recognition (thanks to the help of a number of freelancers, in particular). Then, we separated all words (depending on their grammatical category) in order to count them. Finally, in this draft database, we have indexed 13,570 different words (with a total of 223,387 tokens). We have then transcribed each word into the international phonetic alphabet (using the phonological forms of the SUBTLEX-UK database – Van Heuven et al., 2014 – and those of the WordReference website for words absent from the SUBTLEX-UK database – *English to French, Italian, German & Spanish Dictionary - WordReference.com*, 2021) to obtain the associated phonological form. Finally, we have calculated or determined various parameters for each word:

- the number of letters, phonemes and syllables, in order to take into account, the length of words in the stimuli selections;
- the number of English homophones and homographs (using the function COUNTIF of the Microsoft® Excel® Software) of each word, in order to exclude words with homophones or homographs from the stimuli selections;
- the grammatical category, as well as gender and number where relevant, in order to select male nouns and adjectives in singular forms, as well as adverbs and infinitive forms of verbs (without the "to");
- the raw lexical frequencies, as well as the frequencies per million, this work aiming to analyse the recognition of words in English as an L2, chosen from specific ranges of frequencies, depending on the particular objectives of each study;

- the number of English (within this draft database) and French (with the Lexique database – New, 2006) orthographic neighbours, their (maximum and mean) written frequencies and the Levenshtein distance with the 20 closest English and French orthographic neighbours (respectively old20-E and old20-F – calculated with LDCalc® Software – Ferrand et al., 2010; Yarkoni et al., 2008), in order to be able to take into account, the within and between language orthographic neighbourhood during the stimuli selections;

- the number of English (within this draft database) and French (with the Lexique database – New, 2006) phonological neighbours, their (maximum and mean) oral frequencies (from the SUBTLEX-UK database for English neighbours – Van Heuven et al., 2014; and from the Lexique database for French neighbours – New, 2006) and the Levenshtein distance with the 20 closest English and French phonological neighbours (respectively pld20-E and pld20-F – calculated with LDCalc® Software – Ferrand et al., 2010; Yarkoni et al., 2008), in order to be able to take into account, the within and between language phonological neighbourhood during the stimuli selections;

- the minimum and mean frequencies of letters, bigrams and trigrams (using a specific program built in Python) calculated within English (using this draft database) and French (using the Lexique database – New, 2006) languages, in order to take into account, the typicality of the language spelling (orthographic markedness);

- the different possible French translation equivalents of words, in order to be able to distinguish cognate and non-cognate words – to make this distinction, we then determined the minimum Levenshtein distance between a word and each of its translation equivalents (mldTE), a threshold having been chosen at 3[11]: a word was then considered as identical cognate for a null mldTE, as non-identical cognate when the mldTE was less than or equal to 3 and not null, and as non-cognate when the mldTE was greater than or equal to 4.

Thus, the data used to select stimuli for each experimental protocol of this thesis work came from this draft database. It will thus be advisable to check the possible modifications of the values of these parameters in the finalized database in order to check the scope of the results obtained here, and to be able, if necessary, to exclude from the analyses certain items that no longer correspond to the parameters defined for the selection.

Alongside the creation of this draft database, it was also necessary to design two questionnaires for the different groups of participants targeted by the experimental protocols. We will now turn to the creation and validation of these questionnaires.

3.2. Design of the questionnaires addressed to the participants of the various experimental protocols.

In order to explore the different research questions, we had also to design two questionnaires, one for adults and one for middle school students, allowing us to collect the (current and past) reading habits, the schooling and the socio-economic status of each of our

[11] This threshold was chosen based on the results of a study among 40 French adults. Four lists of word pairs (French and English translation equivalents, without identical cognate words) were randomly distributed among the participants. They had to decide whether they thought the words were cognates or not. Each pair of words was then associated with the corresponding mldTE. A threshold of 3 was thus determined as the best discrimination threshold. For the stimuli selections were excluded a posteriori all the words with an mldTE higher than 3 but considered as cognate by at least one of the members of the project team (composed of Camille Cornut, PhD student; Prof. Séverine Casalis, PhD supervisor; Dr. Gwendoline Mahé, PhD co-supervisor; and Dr. Lynne Duncan, supervisor of Camille Cornut's InDoc internship in Scotland).

participants. In addition, since some of our experimental protocols were designed to compare typical and dyslexic-readers, we also needed to include questions about the dyslexia diagnosis made and the resulting management. Finally, since this thesis work deals with bilingualism, we include questions about the language experiences.

3.2.1. Questionnaire addressed to middle school students.

For middle school students, our questionnaire was entitled "Habitudes de lecture de l'enfant et disponibilité des livres" (translation: *"Child's Reading Habits and Book Availability"*) and was inspired by: a) the Reading Interest Scale from Panigrahi and Panda (2017) which explores reading interests for various types of documents and various subjects of text books, time spent on reading, approach to different sources of information and factors hindering from regular reading ; b) the reading habits / book availability scale from Tella and Akande (2007) adapted from the Reading Habits Pilot Survey from Darko-Ampem (2004) ; and c) the Hollingshead Four-Factor Index of Social Position (Hollingshead, 1975; Myers et al., 1968). We also included questions about the language experiences. The modified questionnaire is available in the Appendix 2 page 299 and was approved by the members of the APPREL2 ANR project. The changes have been made to ensure clarity and relevance to the reading habits of French children.

3.2.2. Questionnaire addressed to university students.

For university students, our questionnaire was entitled "Questionnaire sur les habitudes de lecture des adultes" (translation: *"Adult Reading Habits Questionnaire"*) and was inspired by: a) the Adult Reading History Questionnaire – revised (Lefly & Pennington, 2000) which explores reading history through reading habits in childhood and adulthood ; and b) the Hollingshead Four-Factor Index of Social Position (Hollingshead, 1975; Myers et al., 1968).

We also included questions about the language experiences. The modified questionnaire is available in the Appendix 3 page 304 and was approved by the members of the APPREL2 ANR project. The changes have been made to ensure clarity and relevance to the reading habits of French people. A translated in English version of this questionnaire was used for English participants.

3.2.3. Validity and reliability of the questionnaires.

Finally, the questionnaires used consisted of a few open-ended questions and mostly closed-ended questions. The questionnaires were written in French. To test the validity and reliability of the questionnaires for their intended purposes, they were administered firstly respectively to 20 middle school students in grades 8 and 9 from different middle-schools in the Hauts-de-France Region and to 20 university students from the University of Lille in the Hauts-de-France Region. These participants were not included in the samples of the experimental protocols of this thesis work. The main objective of these first recruitments was to determine the adequacy of our new questionnaires and the level of understanding of the questions, as well as the time it would take to complete each questionnaire. The reliabilities were tested with Cronbach's alpha, and yielded respectively a $\alpha = .734$ for the questionnaire addressed to middle school students, and a $\alpha = .886$ for the questionnaire addressed to university students.

These questionnaires being created, we had to choose how to assess L2 Proficiency of our participants, as we will now explain.

3.3. L2 Proficiency positioning test choice.

In most of psycholinguistic studies dealing with bilinguals, the assessment of L2 proficiency was performed through two different tools: a) self-assessment questionnaires; or b) Lextale test (Lemhöfer & Broersma, 2012). However, Veivo's team used the Dialang test

(*Dialang*, 2021) provided by the Lancaster University (Veivo, 2017; Veivo et al., 2015; Veivo & Järvikivi, 2013), which was interesting because of the variety of testable languages it offers (see for a review of this test: Chapelle, 2006).

Dialang test is a placement test in several languages that allows the assessment of the level of proficiency in 14 languages, according to the Common European Framework of Reference (CEFR; Council of Europe, 2001). This is an online test, allowing the evaluation of 5 communication skills: (a) oral comprehension skills (*i.e.*, comprehension skills from oral sentences); (b) written expression skills (*i.e.*, ability to complete sentences with the correct word, to decide which sentence is not a part from a text, or to judge if sentences are correct or not); (c) written comprehension skills (*i.e.*, comprehension skills from written sentences); (d) grammatical structure knowledge (*i.e.*, grammatical skills); and (e) written vocabulary knowledge (*i.e.*, capacity to choose the correct word to express an idea or a specific meaning, in written form). For each skill, Dialang evaluates the level of proficiency and gives a code corresponding to the CEFR (between A1 and C2). Dialang also offers a self-assessment, to compare the self-estimation with the results of the tests and a first level assessment (called Dialang_Level – DL), with a lexical decision task, leading to a score out of 1,000.

Our first experimental protocol was inspired by Veivo's work. We thus decided to use Dialang test. In order to validate this L2 proficiency assessment test for French-English bilinguals, we conducted an online study to compare English language proficiency assessment through Dialang and Lextale on the Psytoolkit platform (Stoet, 2010, 2017). We used the first level assessment of Dialang because it is a lexical decision task, as is the case for Lextale. We recruited 64 French adults. All of them were native-speakers of French. They had learned English as an L2 in a school context in France. They had no hearing problems and normal or corrected-to-normal vision. None of them reported any kind of learning impairment. All participants gave their written informed consent, directly through the Psytoolkit platform, and the study was approved by the Lille University Ethics Committee (Authorization # 2018 -263-S58). We counterbalanced the order of presentation of the two tests across participants. Demographic data are available in Table 1 below[12].

Table 1. Demographic data - Dialang *vs.* Lextale.

Data	Mean (SD)
Age	28 (9)
Gender (% of Female)	83
Age of formal acquisition of English as an L2	10 (2)
Exposure to French language[13]	1.23 (0.81)
Exposure to English language[13]	2.59 (1.21)

The results of those two tests were highly correlated, as displayed by Figure 7 below, with a correlation coefficient r = .781 which was significant (t(62) = 9.847, p < .001, 99% confidence interval = [.635; 1]).

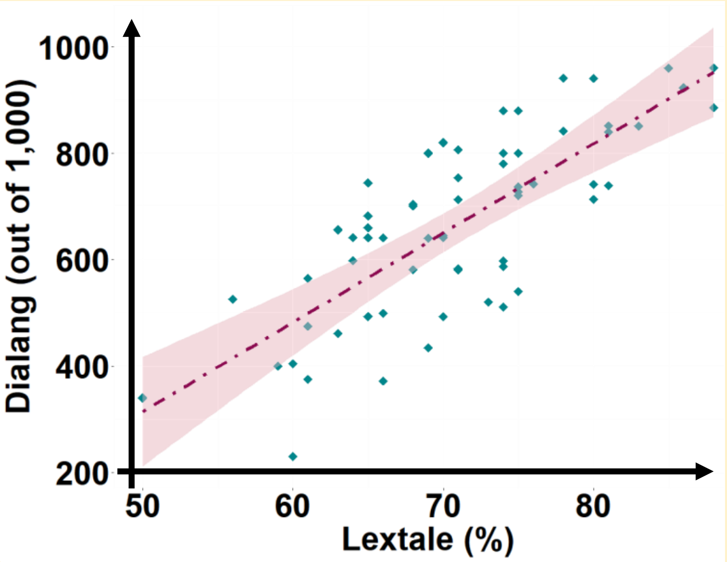


Figure 7. Dialang score (out of 1,000) as a fonction of Lextale score (percent): dotdashed line is the regression line, the area around is the 99% confidence interval.

[12] To simplify the readability of this manuscript, the tables of statistical modeling results will always be presented in green boxes. The graphs will be inserted in boxes with a yellow background. The tables summarizing the results by group will be presented with an orange background. Finally, the global summaries of the results of each experiment will be on a blue background.

[13] Self-estimation by each participant on a scale from 1 (extremely frequent) to 5 (extremely rare).

Dialang-Level and Lextale tests seemed therefore both relevant to assess L2 proficiency among French-English late bilinguals, who have learned English in an academic context in France.

Now that the requirements of the different protocols have been defined, we can detail the framework chosen to analyse the data for each of the six experiments.

3.4. Framework of data analyses.

First, let us detail the dependent variables chosen for the various analyses.

3.4.1. Dependent variables.

This thesis work aims to study the impact of L2 word presentation modality during their recognition, and thus during lexical decision tasks. We therefore made a point of analysing three main dependent variables of the experimental protocols: the discrimination rate between words and pseudowords (**d'**), the **accuracy** of word recognition and the **latencies** of correct word recognition.

First, we used the signal detection theory approach to analyse the discrimination rate between words and pseudowords for all participants performing a task (Green & Swets, 1966; Macmillan & Creelman, 1991). Discrimination rate (d') allowed us to determine the extent to which each participant was able to discriminate words and pseudowords.

We then analysed the Response (correct *vs.* incorrect, and thus the Accuracy scores) of each participant on word trials only. For this analysis, we excluded participants who did not perform the task correctly, thus responding randomly. In order to identify them, we calculated for each task the Error Rate corresponding to a Random Response (ER_3 – using a binomial law of parameters n – number of stimuli in the task – and p = .5 – probability of random response since it was a forced choice task with two possibilities). Thus, we excluded from the analyses those participants whose pseudoword[14] error rates were higher than the ER_3 of the given task. Likewise, we excluded from the analyses the items being outliers from the boxplots, in terms of accuracy scores, and thus being far less well recognized than the other items.

Finally, we analysed latencies for correct word trials, on the basis of the same participants and items as the analysis of accuracy scores.

The main aim of this work being to determine whether a modality effect exists, which would notably affect latencies, we needed to select in advance which main parameter will be analysed, in order to correctly select the stimuli. Indeed, if this modality effect exists, it could induce a facilitation of L2 word recognition in one modality, compared to the other, manifested by: a) higher accuracy scores; b) lower latencies; or c) both higher accuracy scores and lower latencies. However, to be able to correctly analyse accuracy scores, it is necessary to avoid floor and ceiling effect, while the complete analysis of reaction times requires a ceiling effect. That is why we decided to propose experiments aiming to analyse accuracy and others aiming to analyse latencies.

Now, we will focus on the main statistical analyses performed for each of those dependent variables, as well as other tests.

3.4.2. Data analyses.

To compare our groups of participants (for demographic data, background tests, …), to perform the pairings (of participants, of items, …), and for post-hoc tests, data analyses were

[14] We have not considered each participant's error rate for words here, as our population of interest consists of late French-English bilinguals with a low to intermediate proficiency in English, and therefore with a relatively poor mental lexicon. Thus, a high error rate on words could reflect not a random response due to a lack of involvement in the task, but honesty as to what words are actually known.

conducted with the software package R-Studio© (RStudio Team, 2015, version 1.2.5033, R version 4.0.3) using the functions t.test and wilcox.test from the package stats (version 3.6.2), with Bonferroni's corrections.

Concerning the different dependent variables, data analyses were conducted with the software package R-Studio© (RStudio Team, 2015, version 1.2.5033, R version 4.0.3) using different packages to perform descriptive and main analyses, with Satterthwaite's correction.

We analysed the d' of each participant using linear mixed-effect modelling (LMM – Baayen et al., 2008) with the function lmer of the package lme4 (Bates et al., 2014). Concerning the random structure, it was simplified through a backward stepwise selection procedure, starting with the most complete random structure justified by the design, and stopping when all random effects resulting in nonconvergence were deleted (Barr et al., 2013). Concerning fixed effects, to determine which model gave the best approximation of reality, we used the Akaike Information Criterion (AIC – Anderson et al., 1998; Burnham & Anderson, 1998) through a top-down selection procedure, starting with all fixed-effect factors and suppressing them one by one until the modal can no longer be upgraded. Finally, we decided to use orthogonal contrasts, with values -.5 and .5, because our independent variables are factors with two modalities and because this type of contrasts would give the real mean differences between the two conditions tested. We then computed the variance components on fixed effects, using the function r.squaredGLMM from the package MuMIn (Barton, 2020). To improve our confidence in the chosen model, and because our target population would probably lead to an heterogeneity of variances (and to the absence of a normal distribution of results), we used Bayesian statistics[15], with the function brm of the brms package (Bürkner, 2017, 2018;

[15] Indeed, Bayesian statistics did not require variance homogeneity and normal distribution of the data in each group, as required by other types of analysis.

Carpenter et al., 2017), with neutral priors[16] (as recommended by Gelman - 2006), to obtain 95% credible intervals (CrI) and posterior distributions for each estimate. We used the function generalTestBF of the BayesFactor package (Morey et al., 2018) to compute the Bayes factors (BF) associated with all the possible Bayesian models compared to the null model (including only the intercept), and to determine if the final model defined with LMM is the most relevant, given the data. Indeed, the BF is the ratio of the probability of the data given a model A and the probability of the data given a model B, those probabilities being marginalized across the parameters within each model. The BF is a score allowing to know how much the prior odds change, given the data. Thus, we could use the magnitude of the BF to decide which model is the most relevant. It is admitted that if BF > 3.0, there is substantial evidence for the model A, whereas there is substantial evidence for the model B if BF < 1/3 (Berger & Pericchi, 1996; Morey et al., 2018; Morey & Rouder, 2011; Rouder & Morey, 2012; Wetzels et al., 2011). The most relevant Bayesian is the one with the maximum BF. We also used the bayes_R2 function of the same package to calculate a Bayesian version of the R^2 (Gelman et al., 2019).

We then analysed the Response (correct *vs.* incorrect, and thus the Accuracy scores) of each participant on word trials only. We analysed this parameter using generalized linear mixed-effect modelling (GLMM, because the dependent variable Response was dichotomic; Quené & Bergh, 2008), with the function glmer of the package lme4 (Bates et al., 2014). The same procedure as above, using the AIC, was used to fit a GLMM with a logit function to the Response of each trial. We performed then the same type of Bayesian statistical analysis to obtain CrI and posterior distributions for each estimate.

[16] Because our experiments are exploratory experiments concerning the main effect analyzed, we decided to use preferentially neutral priors, instead of using the results of the LMM, in order to avoid a huge effect of priors on the resulting estimate posterior distributions. Indeed, neutral prior distribution (uniform distribution centered at zero) implies no biasing influence on posterior distribution (Kruschke, 2015).

Finally, we performed the main analyses on reaction times using LMM, with the function lmer of the package lme4 (Bates et al., 2014). We used the same procedure as above for d'. We performed then the same type of Bayesian statistical analysis as for d', to obtain CrI[17] and posterior distributions for each estimate and to calculate a Bayesian version of the R^2 (Gelman et al., 2019).

All these preliminary considerations being defined, we can now describe each of the experimental protocols of this thesis project. Let's start with Experiment 1 that aims to demonstrate the existence of a modality effect during L2 word recognition, mainly in terms of accuracy.

[17] CrI are also called Highest Density Interval (HDI) and correspond to the span of values that are most credible (Kruschke, 2015).

Chapter 4. Experiment 1: Does modality matter in L2 word recognition accuracy?

4.1. Introduction.

L2 word recognition, the first stage of word processing, is a crucial mechanism, fully investigated throughout the literature. However, most of studies on L2 word recognition considered one modality only during task completion. Thus, very little information is available on the specific impact of modality on L2 word recognition, a direct comparison between modalities being absent from the literature (see for a comparison of translation skills between modalities: Veivo et al., 2015). The question then arises about the impact of modality on L2 word recognition. This is a main issue, especially for intermediate proficiency bilinguals, such as late bilinguals who have learned the L2 in an academic context – and thus with a bias in exposure in favour of the written modality. The current study thus aimed to determine whether a modality effect exists on L2 word recognition in terms of accuracy[18] among intermediate proficiency bilinguals, taking into consideration both non-cognate and cognate words[19].

Considering L2 word recognition, the crucial issues are whether and when word recognition mechanisms and the lexicon are shared between L1 and L2 during L2 acquisition among late bilinguals. Note that most of French people learn English as an L2 in an academic context, as is also the case for English people learning French as an L2. In addition, the practicalities of L2 learning in an academic context imply a bias in exposure in favour of the written modality. L2 learners have thus fewer occasions to create phonological representations

[18] As a reminder, accuracy and latencies were impossible to analyze through the same paradigm, due to technical considerations, concerning notably item selection.

[19] See Chapter 1. for the specific interest of cognate words for the analysis of modality impact on word recognition.

of L2 words, and consequently a limited access to the phonological form of L2 written words. They need to use OPM[20] to decode new encountered words, while the inconsistency of English orthography and its incongruence with French one make them uncertain of the correct OPM to use (notably because of a co-activation of both – L1 and L2 – conversion systems, see Commissaire et al., 2019). One might thus expect **a modality effect, in favour of the written modality**, on L2 word recognition among French-English late bilinguals, as among English-French late bilinguals, the practicalities of L2 learning in both English and French academic systems being relatively similar. To our knowledge, only one study examined the impact of modality in a situation of multilingual word processing, through a translation task, highlighting a modality effect in L3 (Veivo et al., 2015). Note that the translation task necessitated a semantic processing, which is of a higher level of complexity than word recognition. Therefore, this study does not allow to clearly determine whether L2 lexical representations are modal-dependant or not.

Critically, most L2 word recognition models consider mostly high proficiency bilinguals (see Boddaert, 2019, for a review). Note that BIA-d (Grainger et al., 2010) described the development of orthographic lexical knowledge among late bilinguals, the organization of relations between translation equivalents of both languages and concepts depending on L2 proficiency. Low proficiency bilinguals are assumed to present an indirect access to meaning *via* translation equivalents, this access being particularly facilitated by cognate words (sharing both semantic and formal aspects). Progressively, with L2 proficiency increase through notably L2 exposure, the links between translation equivalents are strengthened. In the same time, direct connections between L2 words and concepts are established, and further enhances, up to the creation of inhibitory links allowing the inhibition of L1 lexical forms during L2 word processing.

[20] OPM = orthography-to-phonology mappings.

The cognate facilitation effect has been extensively investigated among bilingual typical-readers, low proficiency bilinguals showing a greater cognate effect in L2 than in L1, and high proficiency bilinguals presenting a similar cognate effect in both languages (see for a meta-analytic review Lauro & Schwartz, 2017). Furthermore, this effect has been mostly studied in written modality, the overlap between two languages sharing the same alphabetic system being based on spelling more than on phonology (*e.g.*, French and English). Thus, one may wonder how this cognate effect manifests itself in oral modality among intermediate proficiency bilinguals.

Actually, cognate words are good candidates to analyse the specificities of L2 word recognition depending on modalities, because of their orthographic but not systematic phonological overlap between translation equivalents. Thus, an **interaction between modality and cognateness** was also expected, as well as an **interaction between modality and L2 proficiency**, in relation to the evolution of lexicon organization with proficiency increase assumed by the BIA-d model (Grainger et al., 2010). The question thus arises as to the existence of similar effects among advanced and beginner L2 learners, particularly in an academic context. Indeed, beginner learners (such as middle-school students, from grades 8 and 9) are assumed to be mainly exposed to L2 at school, and thus through written materials, while advanced learners (such as university students) L2 exposure is assumed to be mainly modulated by the oral modality (through medias notably).

Furthermore, bilingual word recognition models being designed to describe this processing among expert-readers, the question arises as to the alteration of L2 word processing among the specific population of dyslexic-readers. Indeed, dyslexic-readers are individuals presenting **written word recognition difficulties**, probably at least partially due to a phonological deficit. This reading impairment is therefore characterized by a lack of accuracy and fluency of written word recognition, and by weak capacities in decoding and spelling.

Additionally, previous studies demonstrated a **close relationship between L1 proficiency and L2 acquisition**, in relation to phonological coding (Lindgrén & Laine, 2011a; Sparks et al., 2012). L2 acquisition would therefore be particularly challenging for people with language impairments, and notably for people with developmental dyslexia, whose phonological deficit leads to an alteration of the access to phonological representations of words, linked to a poor acquisition of grapheme-phoneme correspondences.

Moreover, the specificities of L2 learning in an academic context in France do not appear to be suitable for dyslexic-readers, given the bias in exposure in favour of the written modality. They would thus experience huge difficulties to achieve high L2 proficiency (and are rarely balanced bilinguals). It is therefore essential to analyse L2 word recognition among this population of bilingual dyslexic-readers, either advanced or beginner L2 learners. Nevertheless, it should be noted that most studies dealing with written word processing difficulties in dyslexia have been conducted in L1 (Hanley et al., 1992; Hanley & Gard, 1995; Valdois et al., 2003). Some studies conducted with groups of dyslexic-readers in bilingual immersion show that their spelling and reading difficulties observed in L1 are also found in L2 (Lindgrén & Laine, 2011a; Palladino et al., 2013). But very little information is available on L2 word processing difficulties, in both modalities, among dyslexic-readers.

Therefore, Experiment 1 aimed to determine if L2 lexical representations are modal-dependent or independent, through a comparison of oral and written skills of students (both French-English and English-French bilinguals) in L2 word recognition. Experiment 1 also addressed the question of the links between the expected modality effect in L2 and L2 proficiency (thanks to a comparison of late bilinguals from a large range of L2 proficiencies), L1 reading efficiency (through the comparison of typical and dyslexic-readers) and language features (*via* the difference in pattern between French-English and English-French bilinguals). To adopt a cross-sectional perspective – to determine whether it depends on skills development, Experiment 1 involved middle-school and university students. Therefore, Experiment 1 was conducted among five groups of participants: a) French university students, all typical-readers; b) French university students, with a comparison of dyslexic and typical-readers; c) French middle-school students, all typical-readers; d) French middle-school students, with a comparison of dyslexic and typical-readers; and e) English university students, all typical-readers.

Experiment 1 addressed the question as to the degree to which the first stage of word processing, namely word recognition, is sensitive to modality among intermediate proficiency bilinguals. Moreover, it aimed to evaluate whether modality and cognate effects interact during L2 word recognition among this population of intermediate proficiency bilinguals, known to show a greater cognate effect in L2 (see for a meta-analytic review Lauro & Schwartz, 2017). We thus designed a specific paradigm, inspired by the second study of Veivo et al. (2015). Indeed, considering the narrow vocabulary breadth in intermediate proficiency bilinguals, we did not expect our participants to know exactly the same L2 words, making it difficult to compare modalities in a between-group design. Therefore, we designed a paradigm using a repetition of stimuli lists during two lexical decision tasks, one in each modality, performed one after the other, and with a counterbalanced order of presentation of modalities across participants. We expected to highlight the existence of a modality effect, with higher accuracy scores in written modality than in oral one, in English among French typical-readers, as well as in French among English typical-readers. We also anticipated amplitude differences of this modality effect between dyslexic and typical-readers on the one hand, and between university and middle-school students on the other hand. Furthermore, the counterbalanced order of presentation of modalities across participants allowed us to exploratory compare the results across sessions, each participant performing two sessions: one in each modality. A session effect could thus indicate a benefit from one modality over the other, with higher accuracy scores in the second session of word recognition than in the first one.

In order to evaluate the interaction between modality and cognate effects during L2 word recognition, we divided Experiment 1 in two parts. The first one included non-cognate items only – and was called the non-cognate task – whereas the second one included cognate and non-cognate items – and was called the cognate task. We expected a strong cognate effect on L2 written word recognition, whereas spoken one was assumed to be less dependent on cognateness because orthographic overlap is much greater than phonological overlap in French-English cognate words. We expected those various effects to be dependent on L2 proficiency. Finally, we anticipated lower amplitudes of the modality effect for dyslexic-readers.

4.2. Method.

4.2.1. Participants.

As mentioned above, Experiment 1 was conducted among five group of participants: two groups of French university students, two groups of French middle-school students and one group of English university students.

4.2.1.1. French university student groups.

The two groups of French university students were recruited from several universities of the Hauts-de-France Region. All of them were native-speakers of French, having learned English as an L2 in a school context in France. They had no hearing problems and normal or corrected-to-normal vision. None of them reported any kind of impairment[21] (*e.g.*, medical or psychological issues) that could alter his/her participation.

[21] Except DD for the group of dyslexic-readers.

We thus recruited a group of 50 participants, from which none of them reported any kind of learning impairment. Two participants with difficulties in written language processing, according to their reading-related background tests, were excluded *a posteriori* from the analyses. The 48 remaining participants constituted the group of French typical-reader university students, randomly divided into two sub-groups: an Oral-Written-TypFrUniv sub-group of 24 typical-readers performing both tasks in the oral modality and then in the written modality, and a Written-Oral-TypFrUniv sub-group of 24 typical-readers performing both tasks in the opposite order of presentation of modalities. Demographic data of these sub-groups (and pairings between them) are available in Appendix 4 page 309.

We also recruited 17 other participants from the same population. All of them reported a diagnostic of developmental dyslexia. Among the 48 typical-reader participants, we selected 17 participants matched with dyslexic-readers on age, gender, laterality, schooling level, socio-economic status, age of acquisition of English, level of proficiency in English and order of presentation of modalities. Appendix 5 page 311 presents the pairings between both groups (typical and dyslexic-readers). The group of dyslexic-readers was randomly divided into an Oral-Written-DysFrUniv sub-group of 8 dyslexic-readers performing both tasks in the oral modality and then in the written modality (matched with an Oral-Written-TypmatchFrUniv sub-group formed by the 8 typical-readers matched), and a Written-Oral-DysFrUniv sub-group of 9 dyslexic-readers performing both tasks in the opposite order of presentation of modalities (matched with a Written-Oral-TypmatchFrUniv sub-group formed by the 9 typical-readers matched). Demographic data comparing the sub-groups of typical and dyslexic-readers are available in Appendix 4 page 309.

4.2.1.2.French middle-school student groups.

The two groups of French middle-school students were recruited from several middle-schools of the Hauts-de-France Region. They presented the same characteristics as university students.

We thus recruited a group of 50 participants, from which none of them reported any kind of learning impairment. Two participants were excluded *a posteriori* from the analyses: one with difficulties in written language processing, according to his/her reading-related background tests, and the other due to a medical antecedent of stroke. The 48 remaining participants constituted the group of French typical-reader middle-school students, randomly divided into an Oral-Written-TypFrMid sub-group of 23 typical-readers performing both tasks in the oral modality and then in the written modality, and a Written-Oral-TypFrMid sub-group of 25 typical-readers performing both tasks in the opposite order of presentation of modalities. Demographic data of these sub-groups are available in Appendix 6 page 312.

We also recruited 17 other participants from the same population. All of them reported a diagnostic of developmental dyslexia. Among the 48 typical-reader middle-school students, we selected 17 participants matched with dyslexic-readers on age, gender, laterality, schooling level, socio-economic status, age of acquisition of English, level of proficiency in English, school and order of presentation of modalities. Appendix 7 page 314 presents the pairings between both groups. As previously, dyslexic-readers were divided into a Written-Oral-DysFrMid sub-group of 8 dyslexic-readers performing both tasks in the written modality and then in the oral modality (matched with a Written-Oral-TypmatchFrMid sub-group formed by the 8 typical-readers matched), and an Oral-Written-DysFrMid sub-group of 9 dyslexic-readers performing both tasks in the opposite order of presentation of modalities (matched with an Oral-Written-TypmatchFrMid sub-group formed by the 9 typical-readers matched). Demographic data comparing the sub-groups of typical and dyslexic-readers are available in Appendix 6 page 312.

4.2.1.3.English university student groups.

Finally, we recruited a group of 39 participants from the University of Dundee (Scotland, United Kingdom). All of them were native-speakers of English, learning French as an L2 in a school context in Scotland. They had no hearing problems and normal or corrected-to-normal vision. None of them reported any kind of learning or other impairments.

They were randomly divided into an Oral-Written-TypEnUniv sub-group of 19 typical-readers performing both tasks in the oral modality and then in the written modality, and a Written-Oral-TypEnUniv sub-group of 20 typical-readers performing both tasks in the opposite order of presentation of modalities. Demographic data of these two groups are available in Appendix 8 page 315.

4.2.2.Questionnaires.

4.2.2.1.French university student groups.

We administered to university students the Adult Reading Habits Questionnaire described above (section 3.2 page 62). The complete analysis of answers is available in Appendix 9 page 316. Dyslexic and typical-readers were similar concerning the exposures to French and English languages. Of course, dyslexic-readers had more difficulties learning to read in primary school and reading currently than typical-readers. However, the number of books read for pleasure each year was similar in both groups.

4.2.2.2.French middle-school student groups.

We administered to middle-school students the Child's Reading Habits and Book Availability Questionnaire (section 3.2 page 62). The complete analysis of answers is available in Appendix 10 page 321. Dyslexic and typical-readers were similar concerning the exposures to French and English languages. Of course, dyslexic-readers had more difficulties learning to read in primary school than typical-readers. However, the current time devoted to read in daily life was similar in both groups.

4.2.2.3.English university student groups.

An English translation of the Adult Reading Habits Questionnaire was administered to the group of English university students. The complete analysis of answers is available in Appendix 11 page 324.

4.2.3.Background tests.

4.2.3.1.French university student groups.

Firstly, a placement test in English was proposed to university students, to assess their level of proficiency in this language, according to the Common European Framework of Reference (CEFR; Council of Europe, 2001). We used the online Dialang test proposed by Lancaster University (*Dialang*, 2021). Because the aim of Experiment 1 was to assess written and oral word recognition, we decided to administer to our participants the following sub-tests of Dialang: self-assessment (DSA), first level assessment (DL), oral comprehension test (DOC) and written vocabulary test (DWV). The results of those subtests are available in Appendix 12 and Appendix 13 pages 326 and 328.

Secondly, some reading-related and neuropsychological tests were administered to the participants, in order to ensure the comparability of our groups and to assess some reading-related skills to detect any difficulty in written language processing, which could have an influence on task completion. The following skills were assessed: reading, phonological and visuo-attentional skills (Alouette reading test, text reading, isolated word dictation, isolated pseudoword dictation, initial phoneme deletion, spoonerism, symbol barrage, picture naming, letter naming from the ECLA16+ battery – Gola-Asmussen et al., 2011), pseudoword reading from the EVALEC battery (Sprenger-Charolles et al., 2005) and non-verbal intelligence from the Raven Progressive Matrix test (Raven & Raven, 1998). Appendix 12 and Appendix 13 pages 326 and 328 present the results of those tests, as well as the statistics comparing the different sub-groups.

Dyslexic and typical-readers were similar concerning visuo-attentional skills and non-verbal intelligence, whereas dyslexic-readers were in difficulties for reading and phonological skills, except for the initial phoneme deletion score. However, they were longer than typical-readers for this test.

4.2.3.2. French middle-school student groups.

The same background tests were administered to the middle-school typical-reader participants. Appendix 14 page 331 presents the pairings between both sub-groups. Dyslexic and typical-readers were similar concerning visuo-attentional skills and non-verbal intelligence, whereas dyslexic-readers were in difficulties for reading and phonological skills. Note that dyslexic-readers were equivalent to typical-readers for the initial phoneme deletion and pseudoword dictation scores. However, they were longer than typical-readers for these tests.

4.2.3.3. English university student groups.

Firstly, the Dialang Level test in French was proposed to English university students, to assess their level of proficiency in this language. Secondly, some reading-related and neuropsychological tests were administered to the participants, in order to assess some reading-related skills to detect any difficulty in written language processing, which could have an influence on task completion. The following skills were assessed: text reading fluency from the YARC battery (Snowling et al., 2009), isolated word and pseudoword reading and word spelling from the WIAT-III battery (Wechsler, 2009), symbol barrage and letter denomination from the ECLA16+ battery (Gola-Asmussen et al., 2011) and non-verbal skills from the Raven Progressive Matrix test (Raven & Raven, 1998). Appendix 15 page 334 presents the results of those tests, as well as the statistics comparing the two sub-groups.

4.2.4. Stimuli of Lexical Decision Tasks (LDT).

For each (cognate and non-cognate) task, the stimuli were selected following a similar procedure, described below. The auditory stimuli were recorded by two native speakers (native English-speaking man and woman) using the software package Audacity© (*Audacity - Copyright © 1999-2018*). Each stimulus had its own associated file. The audio files were 44,100 Hz stereo wav files and lasted about 1,000 ms. Male and female voices were randomly counterbalanced across participants.

A pilot study among 20 middle-school students from grades 8 and 9 demonstrated that the same stimuli could not be used for university and middle-school students. Indeed, a significant number of them were not known by middle-school students – who were beginner learners of English – leading to random responses. We thus selected different English stimuli for French university and middle-school students.

Finally, we proposed to English university students a cognate task in French only, for which a new list of stimuli was created. Indeed, it seems important to us to analyse cognateness. However, the difficulty to select items for both a cognate and a non-cognate tasks leads us to propose them one task only, namely the cognate task.

4.2.4.1. French university student groups.

Words were selected from a draft database of the APPREL2 ANR project (grant from the National Research Agency 16-CE28-0009-01), using the following criteria: frequency between 10 and 50[22] per million in written form, frequency between 10 and 50 per million in oral form according to the SUBTLEX-UK© database[23] (Van Heuven et al., 2014), 3-to-12 letter-long, no homophones or homographs (in English and also in French), no plurals or conjugated forms. From this first list, we then selected words for the two different tasks: with and without cognate words.

4.2.4.1.1.Stimuli for the non-cognate task.

For the non-cognate task, we selected 44 non-cognate words (mldTE ≥ 4). Sixty-one percent were monosyllabic, others were disyllabic. All words were 3-to-8 letter-long. We then used the software package Wuggy© (Keuleers & Brysbaert, 2010) to create a list of 44 pseudowords matched with the selected words. For the pairings, the following criteria were taken into account:

- ✓ no homophonic forms in either language;
- ✓ length: number of letters, phonemes and syllables;
- ✓ orthographic neighbourhood: number of orthographic neighbours, mean and maximum frequencies of orthographic neighbours, old20;
- ✓ phonological neighbourhood: number of phonological neighbours, mean and maximum frequencies of phonological neighbours, pld20;
- ✓ orthographic markedness: minimum and mean frequencies of letters, bigrams and trigrams.

Orthographic neighbourhood, phonological neighbourhood and orthographic markedness were taken into consideration both in English (within-language parameters) and in

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[22] The aim of Experiment 1 was mainly to analyze accuracy of word recognition. Thus, we chose this specific range of frequency in order to avoid any floor or ceiling effect.

[23] It existed no database providing lexical frequencies in oral form for L2 learners. That is why we decided to use this database, commonly used for experiments among monolinguals.

French (between-language parameters). Appendix 16 page 335 presents the pairings and the complete lists of stimuli for the non-cognate task for university students.

4.2.4.1.2.Stimuli for the cognate task.

For the cognate task, we selected 60 new words into the first list, excluding the words used in the non-cognate task. Given the difficulty to select cognate words in our specific range of frequency, we extended our selection criteria with longer words. Finally, words were monosyllabic (35%), disyllabic (43%), trisyllabic (15%) and quadrisyllabic (7%)[24]. Word frequencies were identical in both tasks (non-cognate and cognate tasks – $t(101.95) = -0.428$, $p > .20$). Among the 60 words, 30 were cognate words (mldTE ≤ 3) and 30 were non-cognate words (mldTE ≥ 4). To evaluate the effect of the amount of orthographic overlap between translation equivalents, 15 out of the 30 cognate words were identical cognate words (mldTE = 0; *e.g.*, "rare") and the other 15 were non-identical cognate words (0 < mldTE ≤ 3; *e.g.*, "honnête" in French / "honest" in English). We used the same procedure as previously to create 60 pseudowords strictly matched with the selected words, using the same pairing parameters. Appendix 17 page 337 presents the pairings and the complete lists of stimuli of the cognate task for university students.

4.2.4.2.French middle-school student groups.

For middle-school students, the same procedure and criteria were used to select words from the draft database of the APPREL2 ANR project, except frequency (between 15 and 80 per million). From this first list of words, we then selected words for the two different tasks: non-cognate and cognate tasks.

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[24] This would probably have an influence on raw latencies. The aim of Experiment 1a being the analysis of accuracy, and mainly a comparison between modalities, this would have no influence on our findings, the same words being used in both modalities.

4.2.4.2.1.Stimuli for the non-cognate task.

For the non-cognate task, we selected 40 non-cognate words (mldTE ≥ 4). Fifty percent were monosyllabic, 47.5% were disyllabic, others were trisyllabic. All words were 3-to-8 letter-long. We then used the same procedure as previously to create a list of 40 pseudowords matched with the selected words, using the same pairing parameters as in previous experiments. Appendix 18 page 339 presents the pairings and the complete lists of stimuli of the non-cognate task for middle-school students.

4.2.4.2.2.Stimuli for the cognate task.

For the cognate task, we selected 60 new words into the first list, excluding the words used in the non-cognate task. Finally, words were monosyllabic (15%), disyllabic (75%), trisyllabic (7%) and quadrisyllabic (3%)[25]. Word frequencies were identical in both tasks (non-cognate and cognate tasks – $t(72.347) = .649$, $p = .518$). As previously, among the 60 words, 30 were cognate words and 30 were non-cognate words, while 15 out of the 30 cognate words were identical cognate words and the other 15 were non-identical cognate words. We used the same procedure as previously to create 60 pseudowords strictly matched with the selected words, using the same pairing parameters. Appendix 19 page 341 presents the pairings and the complete lists of stimuli of the cognate task for middle-school students.

4.2.4.3.English university student groups.

Words were selected from the LEXIQUE database (New, 2006), using the following criteria: frequency between 5 and 55[26] per million in written and in oral forms, 3-to-12 letter-

[25] This would probably have an influence on raw latencies. The aim of Experiment 1a being the analysis of accuracy, and mainly a comparison between modalities, this would have no influence on our findings, the same words being used in both modalities.

[26] The aim of Experiment 1e was mainly to analyze accuracy of word recognition. Thus, we chose this specific range of frequency in order to avoid any floor or ceiling effect.

long, no homophones or homographs (in English and also in French), no plurals or conjugated forms. From this first list of words, we then selected 60 words. Finally, words were monosyllabic (16.67%), disyllabic (43.33%), trisyllabic (30%), quadrisyllabic (6.67%) and pentasyllabic (3.33%). As previously, among the 60 words, 30 were cognate words and 30 were non-cognate words, while 15 out of the 30 cognate words were identical cognate words and the other 15 were non-identical cognate words. We used the same procedure as previously to create 60 pseudowords strictly matched with the selected words, using the same pairing parameters. Appendix 20 page 343 presents the pairings and the complete lists of stimuli for English university students.

4.2.5. Procedure.

All participants were tested in a quiet room at their university or middle-school, on the same testing apparatus. They performed the two tasks in English (non-cognate and cognate tasks), one after the other, with about a 10-minute break. We decided not to counterbalance the order of tasks to avoid an effect of cognate words during the non-cognate task. For each task, the same list of stimuli was used in both modalities, with a randomly counterbalanced order of presentation of modalities across participants. Thus, participants performed two sessions per task: one in written modality and one in oral modality. There was a short break within each session (5 min). Each LDT session (lasting about 5 minutes) was preceded by practice trials with verbal feedback from the examiner.

The experiment was run using the DMASTR software (DMDX© version 5.1.5.3) developed at Monash University and at the University of Arizona by K.I. Forster and J.C. Forster (Forster & Forster, 2003). The stimuli were shuffled for each session and each participant by the DMASTR software itself.

For the written modality LDT session of each task, stimuli were presented on a 15.6" Full HD laptop (Dell Precision Mobile 3520, Processor i5-7440HQ) with a refresh rate of 60 Hz and a resolution of 1,920 x 1,080 pixels. The monitor was placed at a distance of about 60 centimetres from the participants. Stimuli were presented in uppercase in Courier New (11-point font size). They appeared as black characters on a white background on the screen through a high-quality graphic card (NVIDIA Quadro M620). The sequence of each trial was the following: (1) a series of hashes (#########) appeared in the centre of the screen for 500 milliseconds; (2) a stimulus (word or pseudoword) was presented in the centre of the screen until the participant's answer or for 4,000 milliseconds maximum if no response was made. The inter-stimuli interval was 200 milliseconds long.

For the oral modality LDT session of each task, the apparatus was exactly the same as for the visual one, but stimuli were played through speakers (Hercules XPS 2.030) with a high-quality audio soundcard included in the laptop motherboard (Dell© Precision Mobile 3520). The procedure was identical to that used in the visual one, except that the stimuli were played binaurally through speakers.

Participants responded on an XBOX© 360 Controller, which does not have time delays with keyboards (Shimizu, 2002). We measured two dependent variables: response (correct or not) and reaction time (in milliseconds) for correct trials.

4.2.6. Statistical analyses.

Data analyses for each group were conducted as mentioned in section 3.4 page 67 for d' and accuracy scores. We analysed those dependent variables with mixed-effect modelling and Bayesian statistics, including Modality (written *vs.* oral), Session (1st *vs.* 2nd), L2-Proficiency (Dialang Level out of 1,000) and their interactions as fixed factors.

The cognate task included in addition Cognateness (cognate *vs.* non-cognate words) and its interaction with all other fixed factors. Secondly, additional analyses separating cognate and non-cognate words were carried out, in order to determine the influence of Cognate-type (identical *vs*. non-identical cognate words). They allowed us to evaluate the effect of the amount of orthographic overlap between translation equivalents on the one hand, and to check if we replicated the results of the non-cognate task and to determine the influence of cognate words included into the lists on non-cognate word recognition when we analysed non-cognate items of the cognate task on the other hand.

Concerning dyslexic-reader participants, the statistical analyses were completely identical than that of typical-reader participants, except that Group (Typical *vs.* Dyslexic-readers) and its interactions with other factors were included into all analyses.

4.3. Results.

In order to easier results following, we proposed you a summary of those results. This summary is the associated file named "Summary of all the results".

4.3.1. French typical-reader university students.

4.3.1.1. Non-cognate task.

We excluded one participant[27] from the analyses, due to his/her high pseudoword error rate, remaining an Oral-Written-TypFrUniv group of 24 participants and a Written-Oral-TypFrUniv group of 23 participants. We also excluded from the analyses one word (*anger*) following the procedure described in section 3.4 page 67.

[27] We performed also the analysis, without the exclusion of this participant. The results were similar to those described in this section.

4.3.1.1.1.Discrimination rate (d').

Raw data are presented in Figure 8 below.

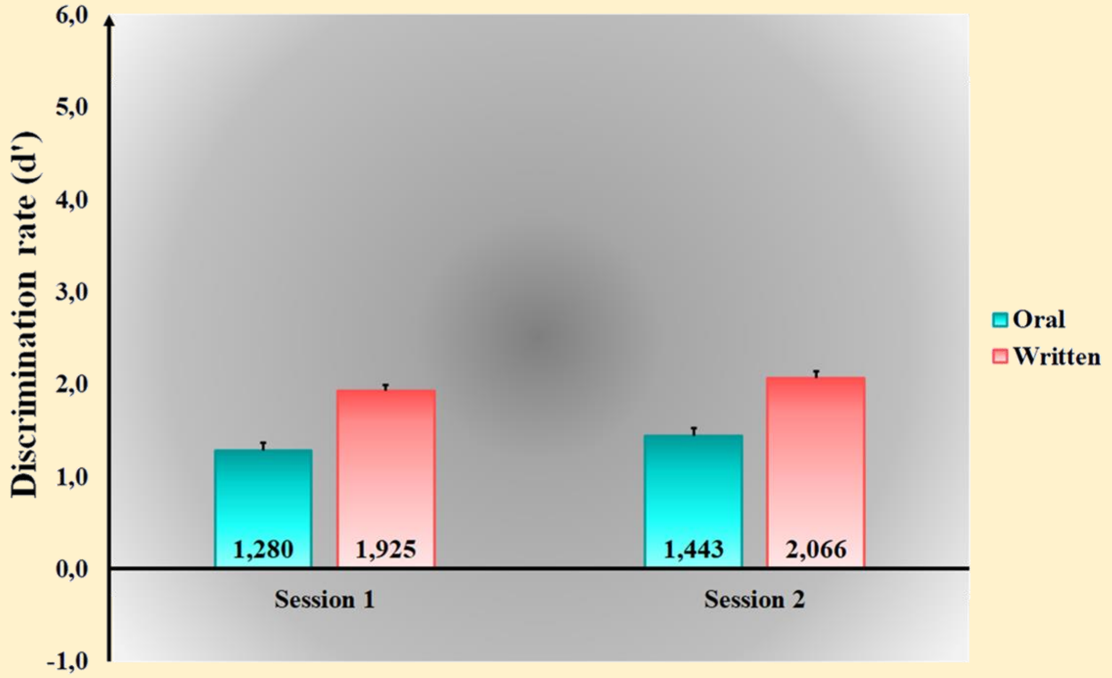

Figure 8. Raw data of d' - Non-cognate task - French typical-reader university students - Experiment 1.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts, and Modality (written *vs.* oral) and centred L2-Proficiency (DL out of 1,000) as fixed effects (best model according to the AIC: $F(1,47) = 64.40$, $p < .001$). Those fixed effects explained 59% of the variance (marginal $R^2 = .585$).

Discrimination rates (d') were significantly lower in oral modality than in written one. In addition, L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .36 of the d' of the participant, as displayed by Figure 9 page 91.

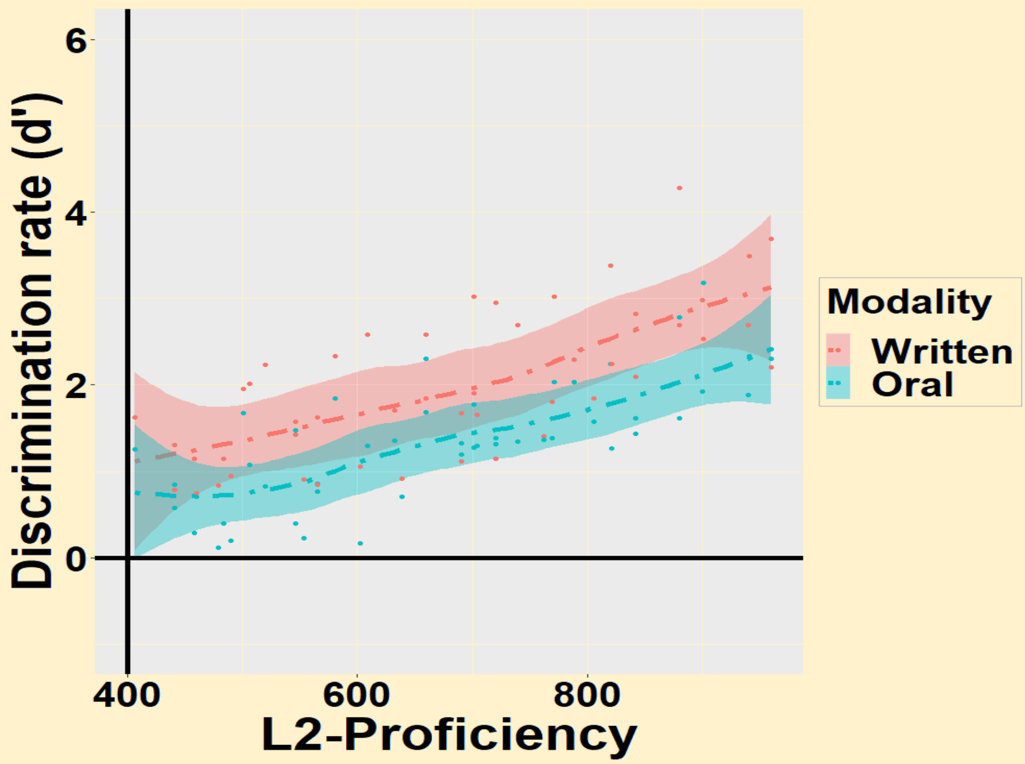

Figure 9. Discrimination rate as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modalities, the areas around are the 99% confidence intervals - Non-cognate task - French typical-reader university students - Experiment 1

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[28], are reported in Table 2 below.

Table 2. Parameter estimates of the final model fitted to the d' (**and output from the Bayesian analysis in bold**) - Non-cognate task - French typical-reader university students - Experiment 1.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	1.68	.07	24.49	<.001*	**1.68**	**.07**	**[1.55;1.82]**
Modality	-.63	.08	-8.03	<.001*	**-.65**	**.08**	**[-.81;-.48]**
L2-Proficiency (DL)	.36	.04	8.23	<.001*	**.35**	**.05**	**[.26;.44]**

*Note: Significant effects at a p < .05 level are marked with a *. Final model formula: lmer(dprime ~ Modality + Dialang_Level + (1 | Participant), data = Data_dprime_Exp1aNCT_Frcntrluniv, REML = TRUE)*

[28] Maximum BF = 4.658 * 10^15, corresponding to the same model formula than those of the final model of LMM (bayes_R² = .78, SE = .04, 95% CrI = [.68, .84]).

4.3.1.1.2.Accuracy scores (percentage of correct responses for word trials).

Mean accuracy scores of our participants, on word trials only, according to Modality and Session are presented in Figure 10 below.

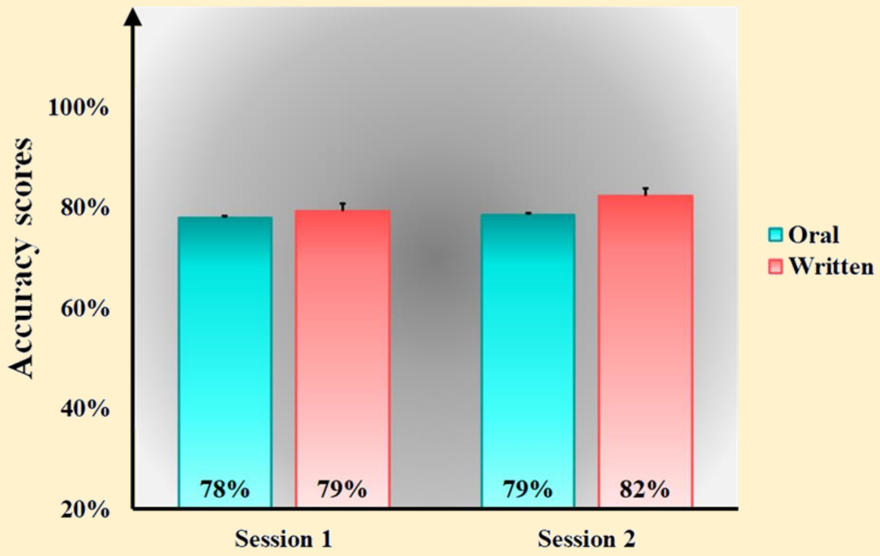

Figure 10. Raw data of Accuracy scores - Non-cognate task - French typical-reader university students - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct *vs.* incorrect) of each participant for each word included by-participant random intercepts and by-item random intercepts and random slope considering the Modality, and L2-Proficiency (DL out of 1,000) and Modality (written *vs.* oral) as fixed effects (best model according to the AIC: $\chi^2 = 62.605$, $p < .001$). Those fixed and random effects explained 29% of the variance (adjusted $R^2 = .289$).

Accuracy scores were significantly lower in oral modality than in written one. In addition, L2-Proficiency effect was significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .49 of the mean accuracy of the participant as displayed by Figure 11 page 93[29].

[29] Note on Figure 11 that the regression line seemed somehow odd in oral modality, displaying a high variability of accuracy scores depending on L2 proficiency in this modality.

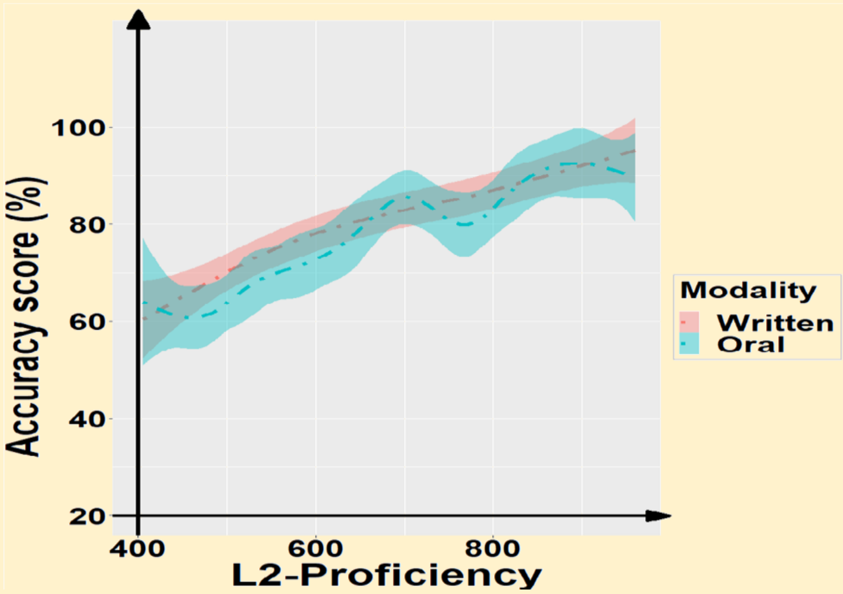

Figure 11. Accuracy score as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modality, the areas around are the 99% confidence intervals - Non-cognate task - French typical-reader university students - Experiment 1.

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[30], are reported in Table 3 below.

Table 3. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - Non-cognate task - French typical-reader university students - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	-1.31	.50	-2.60	<.01*	**-1.33**	**.54**	**[-2.39;-.30]**
L2-Proficiency (DL)	.49	.07	7.23	<.001*	**.49**	**.07**	**[.36;.63]**
Modality	-.49	.21	-2.37	<.05*	**-.50**	**.23**	**[-.97;-.06]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(Response ~ Dialang_Level + Modality + (1 | Participant) + (1 + Modality |Item), data = Data_response_words_Exp1aNCT_Frcntrluniv, family = binomial)

[30] Maximum BF = 4.647 * 10^46, corresponding to the same model formula than those of the final model of LMM (bayes_R² = .27, SE = .01, 95% CrI = [.25, .29]).

4.3.1.2. Cognate task

There was no participant presenting high pseudoword error rate in the Cognate task. However, in order to be able to compare properly both the Non-cognate and the Cognate tasks, we decided to exclude from the analysis for the Cognate task the same participant who was excluded from the analysis for the Non-cognate task[31]. We also excluded from the analyses two words (*garage* and *rogue*) following the procedure described in section 3.4 page 67.

4.3.1.2.1. Discrimination rate (d'), cognate and non-cognate items.

Raw data are presented in Figure 12 below.

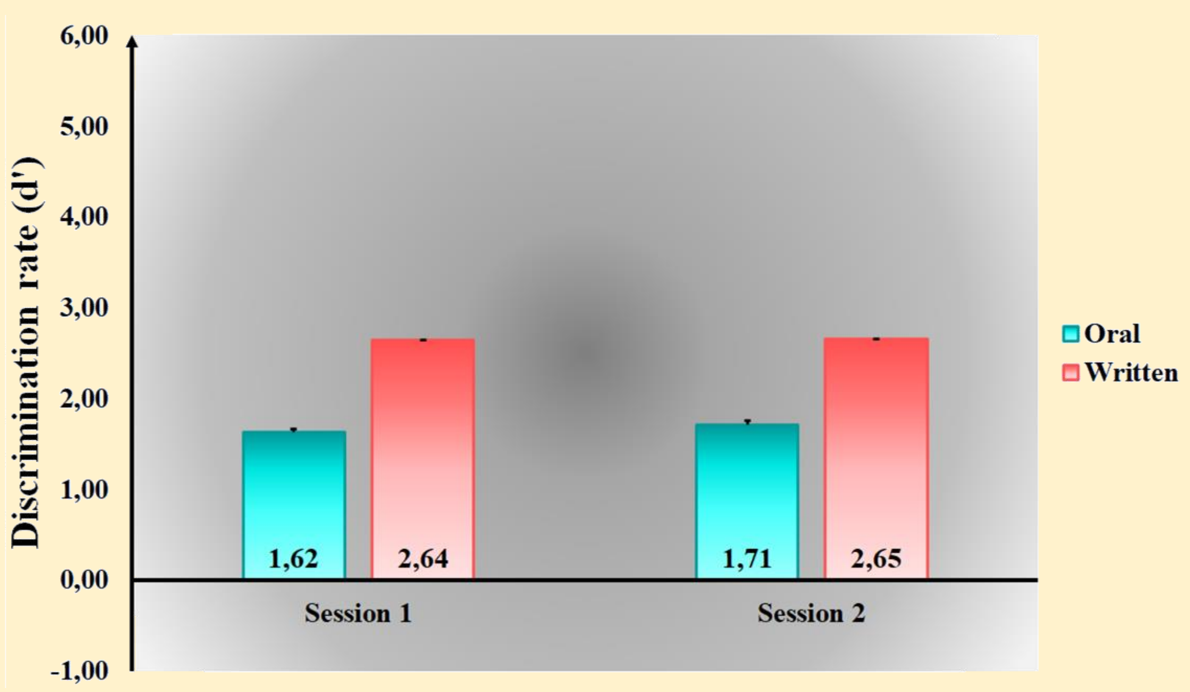

Figure 12. Raw data of d' - Cognate task - French typical-reader university students - Experiment 1.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts and random slopes considering the Modality, and Modality (written *vs.* oral) and centred L2-Proficiency (DL out of 1,000) as fixed effects (best model according to the AIC: $F(1,80) = 141.04$, $p < .001$). Those fixed effects explained 50% of the variance (marginal $R^2 = .501$).

[31] As previously, we performed the same analysis including this participant. The pattern of results was identical.

Discrimination rates (d') were significantly lower in oral modality (1.669, SD = .75) than in written one (2.646, SD = .83). In addition, L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .28 of the d' of the participant, as displayed by Figure 13 below.

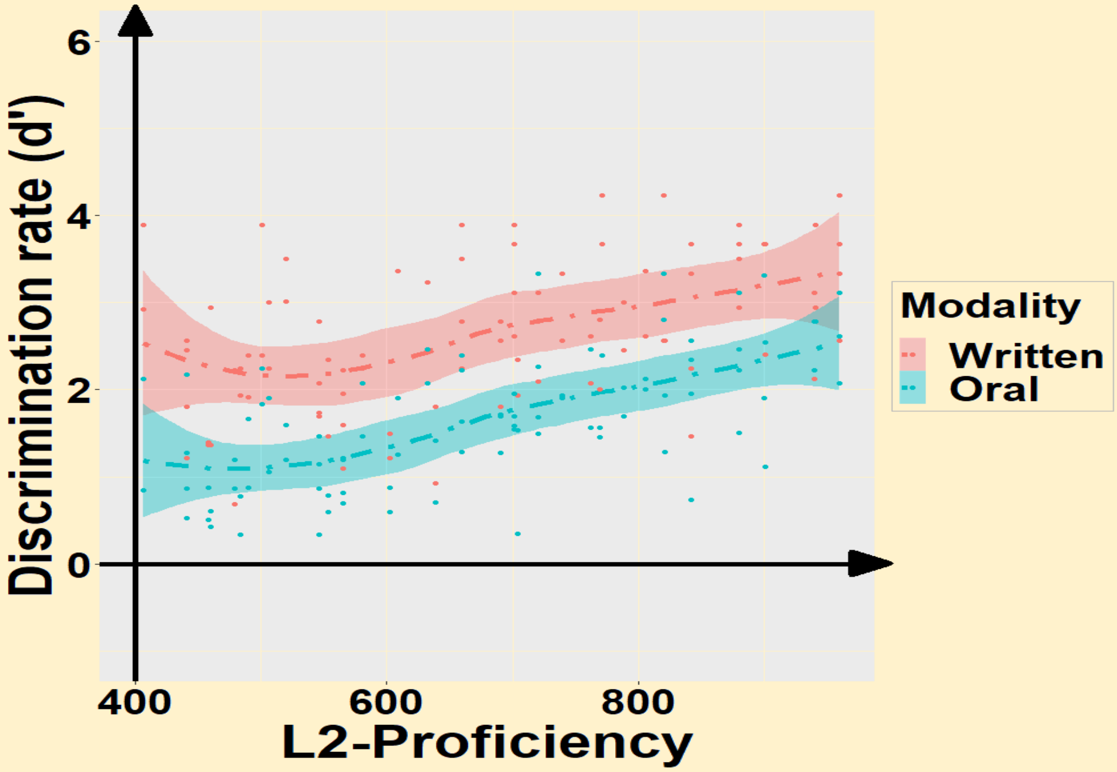

Figure 13. Discrimination rate as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modalities, the areas around are the 99% confidence intervals - Cognate task - French typical-reader university students - Experiment 1

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[32], are reported in Table 4 page 96.

[32] Maximum BF = 1.430 * 10^25, corresponding to the same model formula than those of the final model of LMM (bayes_R^2 = .68, SE = .03, 95% CrI = [.62, .74]).

Table 4. Parameter estimates of the final model fitted to the d' (**and output from the Bayesian analysis in bold**) - Cognate task - French typical-reader university students - Experiment 1.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	2.16	.07	31.38	<.001*	**2.16**	**.07**	**[2.02;2.29]**
Modality	-.98	.08	-11.88	<.001*	**-.97**	**.09**	**[-1.14;-.81]**
L2-Proficiency (DL)	.28	.04	6.98	<.001*	**.28**	**.04**	**[.20;.36]**

Note: Significant effects at a p < .05 level are marked with a ∗*. Final model formula: lmer(dprime ~ Modality + Dialang_Level + (1 + Modalite | Participant), data = Data_dprime_Exp1CT_Frcntrluniv, REML = TRUE)*

4.3.1.2.2.Accuracy scores (percentage of correct responses for word trials), cognate and non-cognate items.

Mean accuracy scores of our participants, on word trials only, according to Modality, Session and Cognateness are presented in Figure 14 below.

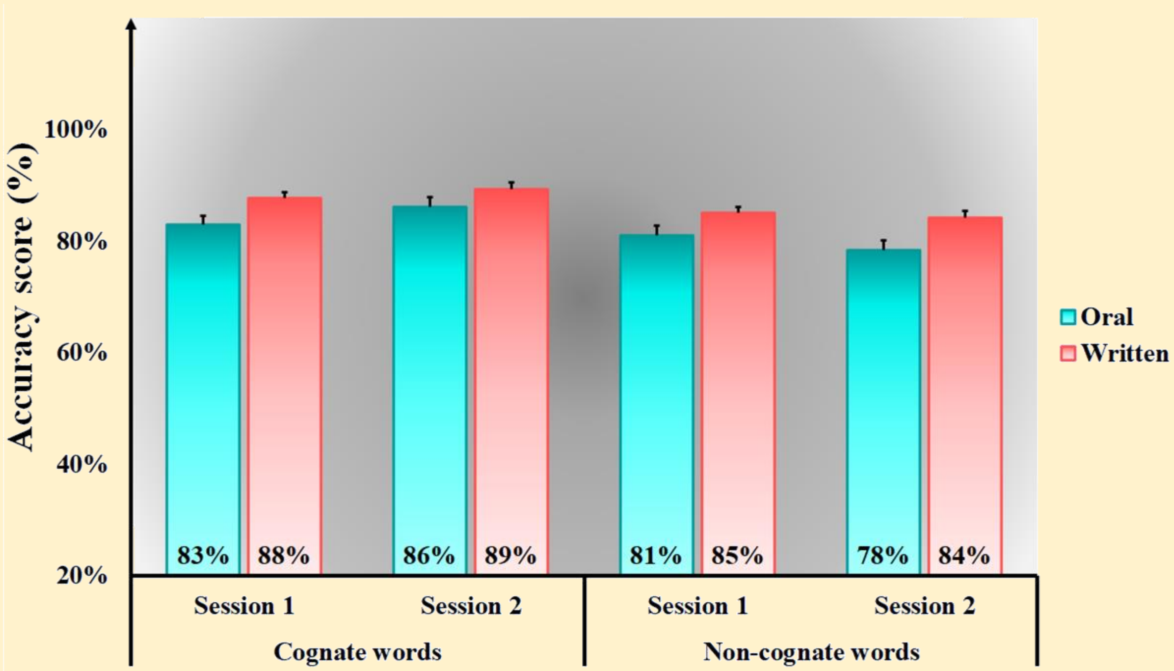

Figure 14. Raw data of Accuracy scores - Cognate task - French typical-reader university students - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct *vs.* incorrect) of each participant for each word included by-participant and by-item random intercepts, and L2-Proficiency (DL out of 1,000), Modality (written *vs.* oral), Cognateness (cognate *vs.* non-cognate) and the two-way interaction between L2-Proficiency and Modality as fixed effects (best model according to the AIC: $\chi^2 = 6.453$, $p < .05$). Those fixed and random effects explained 12% of the variance (adjusted $R^2 = .115$).

Accuracy scores were significantly lower in oral modality (82%, SD = 38) than in written one (87%, SD = 34). L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .37 of the mean accuracy of the participant. Moreover, the two-way interaction between L2-Proficiency and Modality was significant, modality effect (*i.e.*, the difference in accuracy scores between modalities) being of higher amplitude for participants from lower proficiency than for those from higher proficiency, as displayed by Figure 15 page 98[33]. Note that cognate effect was non-significant. However, the Bayesian analysis demonstrated that the estimate associated with Cognateness was different from zero (see Table 5 page 98), accuracy scores being lower for non-cognate words (82%, SD = 38) than for cognate words. (87%, SD = 34).

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[34], are reported in Table 5 page 98.

[33] Note on Figure 15 that both regression lines seemed somehow odd for the lowest proficiency participants, probably in relation to their limited number, compared to higher proficiency participants. That is why we used the centred L2 proficiency as fixed effect, instead of raw values, to avoid an effect of the "sample size" of each range of proficiency.

[34] Maximum BF = 1.177 * 10^53, corresponding to the same model formula than those of the final model of LMM (bayes_$R^2 = .27$, SE = .01, 95% CrI = [.25, .29]).

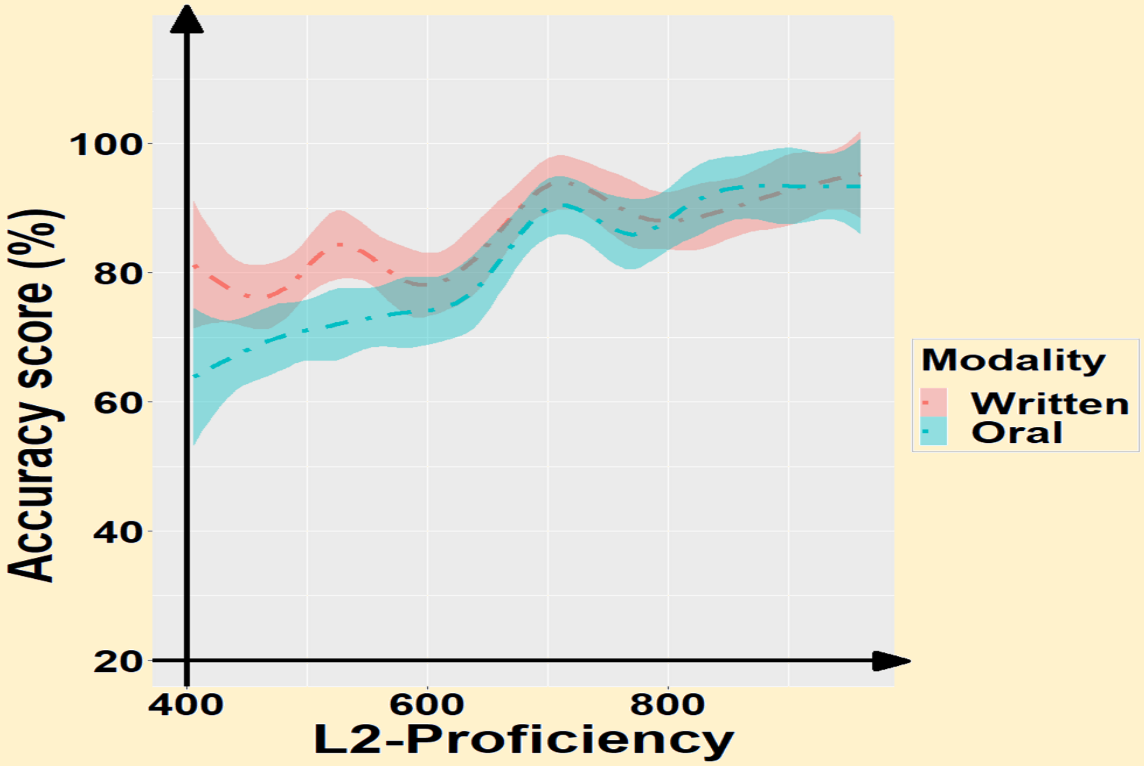

Figure 15. Accuracy score as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modality, the areas around are the 99% confidence intervals - Cognate task - French typical-reader university students - Experiment 1.

Table 5. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - Cognate task - French typical-reader university students - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	1.89	.09	21.72	<.001*	**1.90**	**.09**	**[1.73;2.09]**
L2-Proficiency (DL)	.37	.06	6.76	<.001*	**.38**	**.06**	**[.27;.49]**
Modality	-.29	.08	-3.53	<.001*	**-.29**	**.08**	**[-.46;-.13]**
Cognateness	-.36	.08	-1.03	.305	**-.36**	**.08**	**[-.52;-.22]**
L2-Proficiency x Modality	.14	.05	2.56	<.01*	**.14**	**.05**	**[.03;.24]**

Note: Significant effects at a p < .05 level are marked with a ⁎*. Final model formula: glmer(Response ~ Dialang_Level + Modality + Cognateness + Dialang_Level:Modality + (1 | Participant), data = Data_response_words_Exp1aCT_Frcntrluniv, family = binomial)*

We will now present additional analysis concerning cognate items only.

4.3.1.2.1.Accuracy scores (percentage of correct responses for word trials), cognate items only.

Because the overlap between French and English is greater in orthography than in phonology, we further explored the cognate effect on L2 word recognition in both modalities by comparing identical and non-identical cognate words. Indeed, identical cognate words are totally identical orthographically, whereas they differ phonologically; and non-identical cognate words differ orthographically and phonologically, despite their semantic overlap. Thus, we performed the same analyses as previously (for accuracy) but including only cognate words[35].

Mean accuracy scores of our participants, on cognate word trials only, according to Modality, Session and Cognate-type are presented in Figure 16 below.

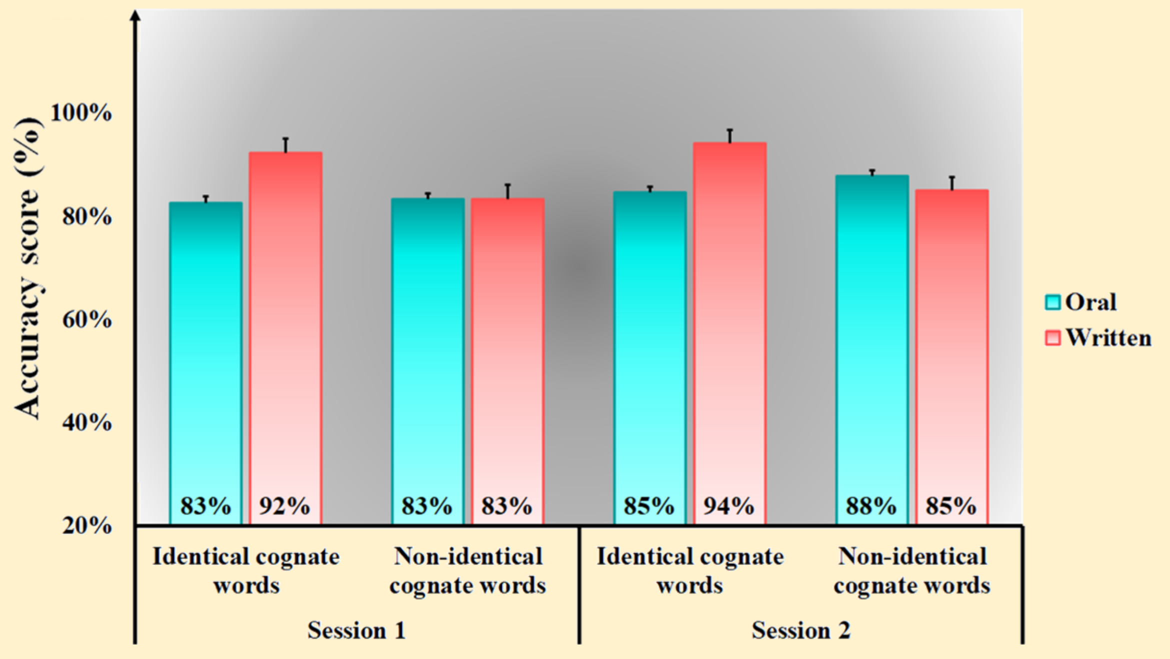

Figure 16. Raw data of Accuracy scores on cognate word trials only - Cognate task - French typical-reader university students - Experiment 1.

[35] Likewise, we performed also additional analysis, similar to that of the non-cognate task, in order to replicate our results and to determine the impact of cognate words included into the lists of stimuli on L2 non-cognate word recognition. The results were similar to those of the non-cognate task.

Final model formula:

The final GLMM fitted to the Response (correct *vs.* incorrect) of each participant for each cognate word included by-participant and by-item random intercepts, and L2-Proficiency (DL out of 1,000), Modality (written *vs.* oral), Cognate-type (identical *vs.* non-identical) and the two-way interactions between L2-Proficiency and Modality, and between Modality and Cognate-type as fixed effects (best model according to the AIC: $\chi^2 = 6.80$, $p < .01$). Those fixed and random effects explained 24% of the variance (adjusted $R^2 = .240$).

Accuracy scores were significantly lower in oral modality (85%, SD = 36) than in written one (88%, SD = 32). L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .45 of the mean accuracy of the participant. Note that the two-way interaction between L2-Proficiency and Modality was significant, modality effect (*i.e.*, the difference in accuracy scores between modalities) being of higher amplitude for participants from lower proficiency than for those from higher proficiency, as displayed by Figure 17 page 101[36]. Moreover, the interaction between Modality and Cognate-type was significant, identical cognate words being recognized more accurately than non-identical ones in written modality, but less accurately in oral modality. In the model including interactions, Cognate-type effect was non-significant. We performed post-hoc analysis to determine if the main effect of Cognate-type was significant. It was the case, non-identical cognate words being recognized less accurately (85%, SD = 36) than identical cognate words (88%, SD = 32; $t(2724) = -2.717$, $p < .01$).

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[37], are reported in Table 6 page 101.

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[36] Note on Figure 17 that the regression line seemed somehow odd for the lowest proficiency participants in written modality, probably in relation to their limited number, compared to higher proficiency participants. This was not visible on the regression line according to the oral modality, because cognate words are closer orthographically than phonologically between languages, having thus less impact on oral word recognition.

[37] Maximum BF = 5.121 * 10^24, corresponding to the same model formula than those of the final model of LMM.

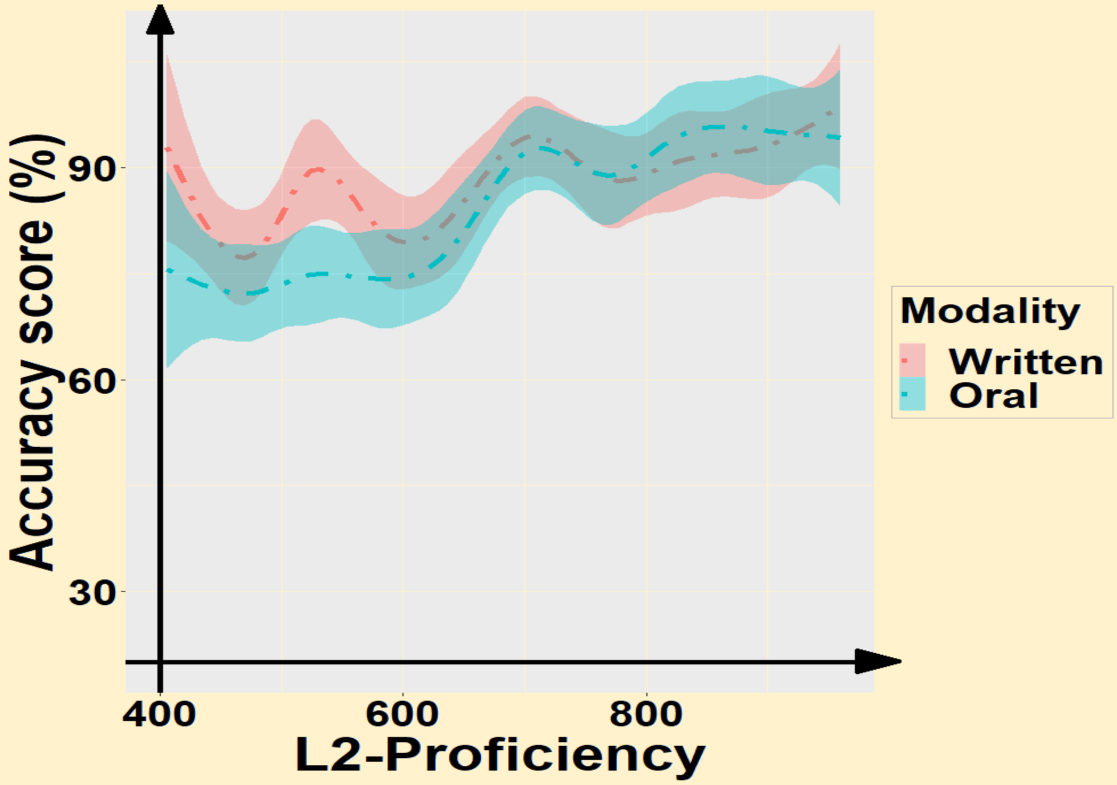

Figure 17. Accuracy score as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modality, the areas around are the 99% confidence intervals - Cognate task, cognate words only - French typical-reader university students - Experiment 1.

Table 6. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) on cognate words - Cognate task - French typical-reader university students - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	2.52	.24	10.62	<.001*	**2.55**	**.26**	**[2.05;3.08]**
L2-Proficiency (DL)	.45	.08	5.87	<.001*	**.46**	**.08**	**[.31;.62]**
Modality	.38	.14	-2.78	<.01*	**-.38**	**.14**	**[-.65;-.11]**
Cognate-type	.19	.42	.44	.659	**.17**	**.46**	**[-.72;1.07]**
L2-Proficiency x Modality	.20	.09	2.34	<.05	**.21**	**.09**	**[.03;.37]**
Modality x Cognate-type	-1.24	.26	-4.82	<.001*	**-1.25**	**.26**	**[-1.76;-.73]**

Note: Significant effects at a p < .05 level are marked with a ∗*. Final model formula: glmer(Response ~ Dialang_Level + Modality + Cognate_type + Dialang_Level:Modality + Modality:Cognate_type + (1 | Participant) + (1 | Item), data = Data_response_cognate_words_Exp1aCT_Frcntrluniv, family = binomial)*

4.3.1.2.2.Summary of the results.

Experiment 1 focused on L2 word recognition among French typical-reader university students. The aims of the study were: a) to explore the impact of modality, both when lists of stimuli included non-cognate words only and when they included both non-cognate and cognate words (characterized by a sharing of both orthography and semantics, while phonology was less shared between translation equivalents); b) to evaluate whether modality and cognate effects interact; and c) to exploratory compare the results across sessions. The main results are summarized in Table 7 below.

Table 7. Summary of the results of Experiment 1 - French typical-reader university students.

(M = Modality, S = Session, P = L2 Proficiency, C = Cognateness, CT = Cognate-type, ✓ = significant effect, ✗ = non-significant effect)

	Dependent Variable	M	S	P	C / CT	M:P	C:M	CT:M
Non-cognate task	d'	✓	✗	✓	NA	✗	NA	NA
	Accuracy	✓	✗	✓	NA	✗	NA	NA
Cognate task / all stimuli	d'	✓	✗	✓	NA	✗	NA	NA
	Accuracy	✓	✗	✓	✓	✓	✗	NA
Cognate task / cognate stimuli	Accuracy	✓	✗	✓	✓	✓	NA	✓

4.3.2.French typical and dyslexic-reader university students.

4.3.2.1.Non-cognate task.

4.3.2.1.1.Discrimination rate (d').

Raw data are presented in Figure 18 page 103.

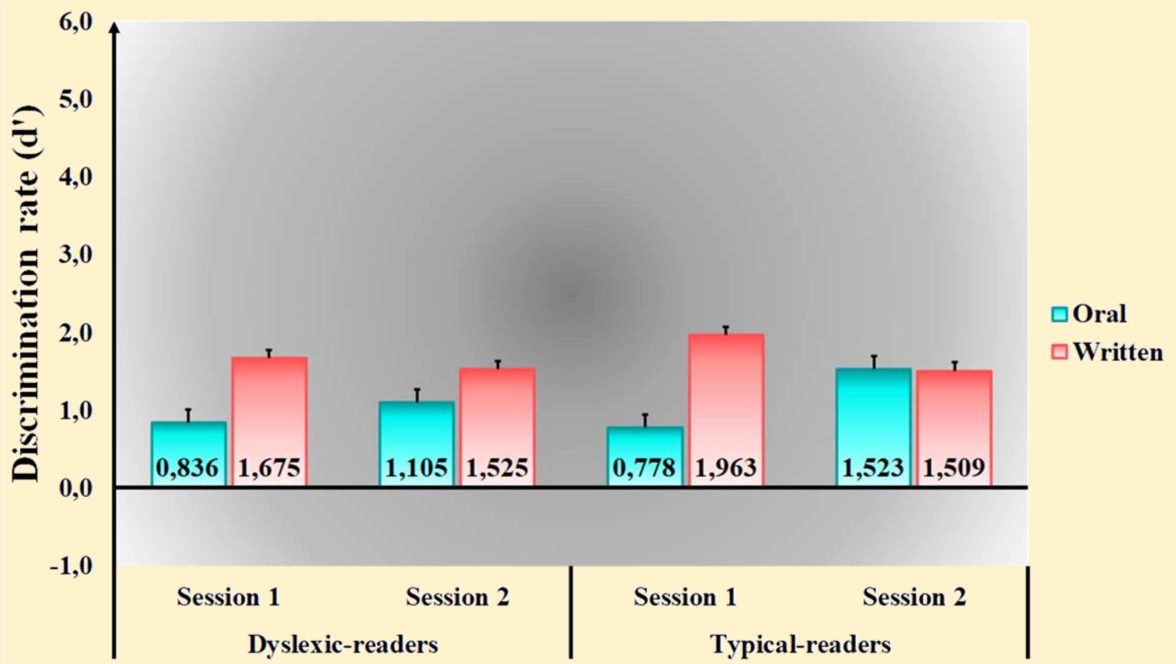

Figure 18. Raw data of d' - Non-cognate task - French university students, dyslexic and typical-readers - Experiment 1.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts[38], and Modality (written *vs.* oral), Session (1st *vs.* 2nd), Group (Dyslexic *vs.* Typical-readers), centred L2-Proficiency (DL out of 1,000), the two-way interactions between Modality and Session, Modality and Group, and Session and Group, and the three-way interaction between Modality, Session and Group as fixed effects (best model according to the AIC: $F(1,29) = 22.89$, $p < .001$). Those fixed effects explained 51% of the variance (marginal $R^2 = .514$).

Discrimination rates (d') were globally significantly lower in oral modality (1.075, SD = .669) than in written one (1.677, SD = .773). In addition, L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .36 of the d' of the participant, as displayed by Figure 19 page 104. Finally, the three-way interaction

[38] We could not include any random slope – according Modality or Session – because we had only one value of d' for each participant by Modality / Session.

between Modality, Session and Group was significant, a session effect (*i.e.*, a difference in d' between sessions), with higher discrimination rates in session 2 compared to session 1, existing in oral modality only for dyslexic-readers, while it was highlighted, with higher discrimination rates in session 2 compared to session 1, in both modalities for typical-readers.

The parameter estimates of the final model fitted to the d' are reported in Table 8 page 105.

The parameter estimates of the best model according to the BF[39] are reported in Table 9 page 105. This model included Modality and L2proficiency only as fixed effects. This model highlighted a significant L2-Proficiency effect, an increase of DL score of 100 out of 1,000 resulting in an increase of .34 of the d' of the participant. In addition, d' were significantly lower in oral modality than in written one.

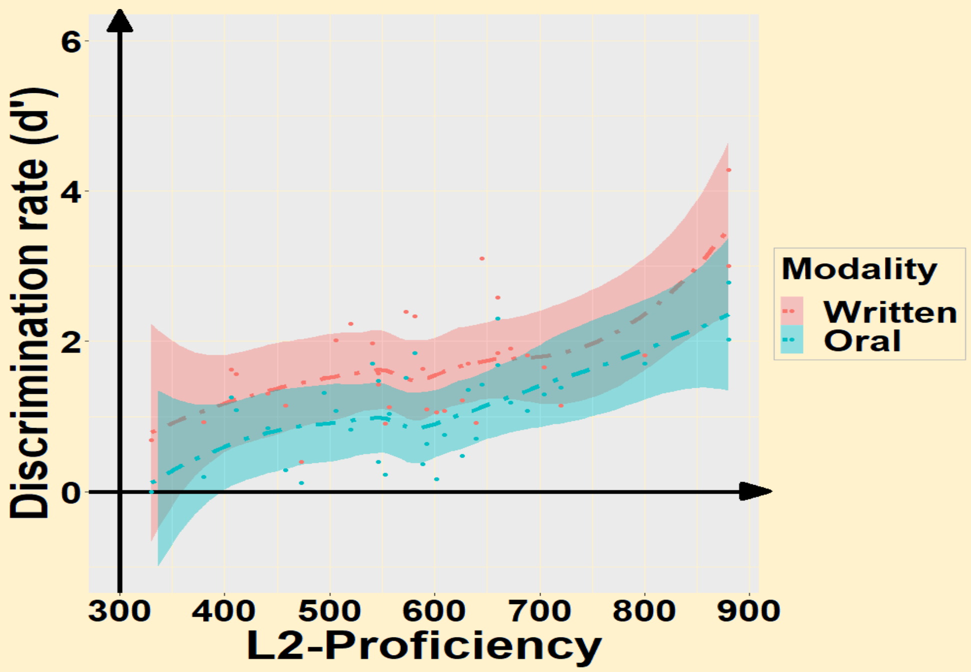

Figure 19. Discrimination rate as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modalities, the areas around are the 99% confidence intervals - Non-cognate task - French university students, dyslexic and typical-readers - Experiment 1

[39] Maximum BF = 4,105,466, corresponding to the same model formula than those of the final model of LMM (bayes_R² = .82, SE = .04, 95% CrI = [.73, .88]).

Table 8. Parameter estimates of the final model fitted to the d' - Non-cognate task - French university students, dyslexic and typical-readers - Experiment 1.

Predictors	b	SE b	t	p
(Intercept)	1.37	.09	15.59	<.001*
Modality	-.61	.08	-7.75	<.001*
Session	.10	.08	1.31	.202
L2-Proficiency (DL)	.36	.08	4.78	<.001*
Group	-.11	.18	-.59	.557
Modality * Session	.30	.37	.81	.424
Modality * Group	-.04	.16	-.28	.784
Session * Group	-.09	.16	-.54	.590
Modality * Session * Group	-1.64	.73	-2.25	<.05*

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(dprime ~ Modality + Session + Dialang_Level + Group + Modality:Session + Modality:Group + Session:Group + Modality:Session:Group + (1 | Participant), data = Data_dprime_Exp1b_NCT_Fruniv_dysctrl, REML = TRUE)

Table 9. Parameter estimates of the best model, according to the BF, fitted to the d' (**and output from the Bayesian analysis in bold**) - Non-cognate task - French university students, dyslexic and typical-readers - Experiment 1.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	1.38	.09	14.86	<.001*	**1.38**	**.10**	**[1.18;1.56]**
Modality	-.60	.08	-7.79	<.001*	**-.60**	**.08**	**[-.77;-.44]**
L2-Proficiency (DL)	.34	.07	4.62	<.001*	**.34**	**.08**	**[.19 ;.49]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(dprime ~ Modality + Dialang_Level + (1 | Participant), data = Data_dprime_Exp1b_NCT_Fruniv_dysctrl, REML = TRUE)

4.3.2.1.2.Accuracy scores (percentage of correct responses for word trials).

Mean accuracy scores of our participants, on word trials only, according to Modality, Session and Group are presented in Figure 20 page 106.

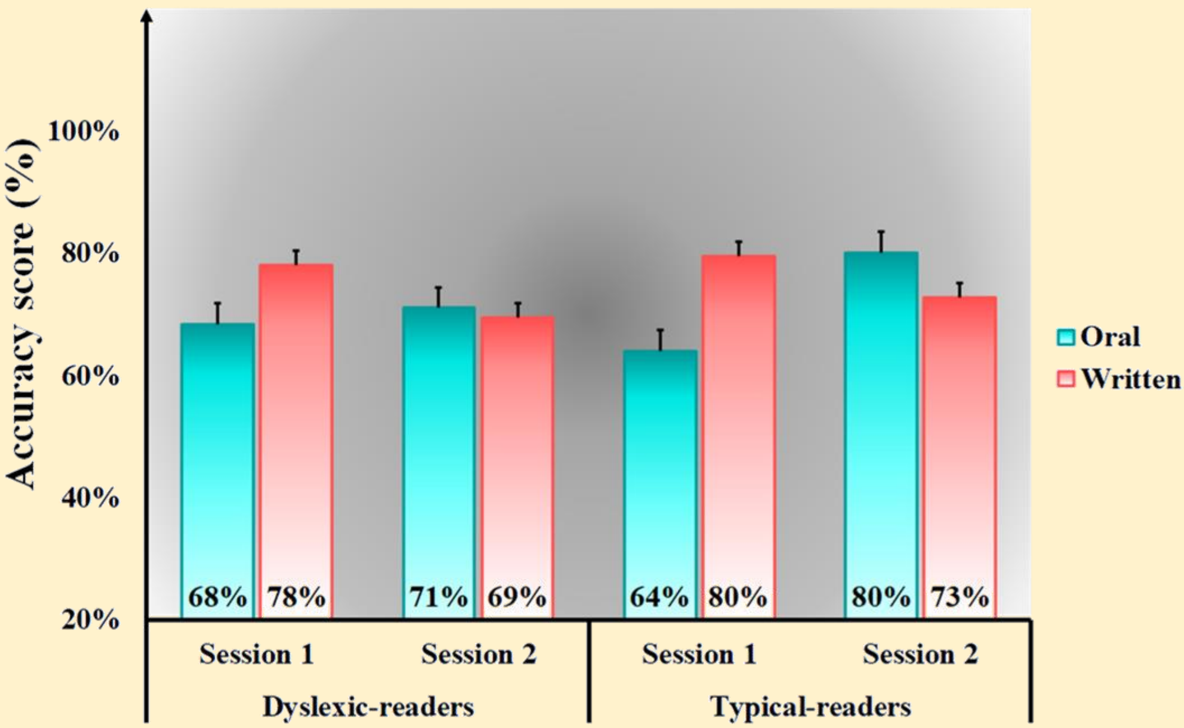

Figure 20. Raw data of Accuracy scores - Non-cognate task - French university students, dyslexic and typical-readers - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct *vs.* incorrect) of each participant for each word included by-participant random intercepts and by-item random intercepts and random slopes considering the Modality, and L2-Proficiency (DL out of 1,000), Modality (written *vs.* oral), Session (1st *vs.* 2nd), Group (Dyslexic *vs.* Typical-readers), the two-way interactions between L2-Proficiency and Session, L2-Proficiency and Modality, Session and Group, and Modality and Session, and the three-way interaction between L2-Proficiency, Modality and Session as fixed effects (best model according to the AIC: $\chi^2 = 10.741$, $p < .01$). Those fixed and random effects explain 29% of the variance (adjusted $R^2 = .285$).

L2-Proficiency effect was significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .34 of the mean accuracy of the participant. Moreover, the two-way interaction between L2-Proficiency and Modality was significant, modality effect being more important for lower proficiency participants than for higher proficiency participants, as displayed by Figure 21 page 107.

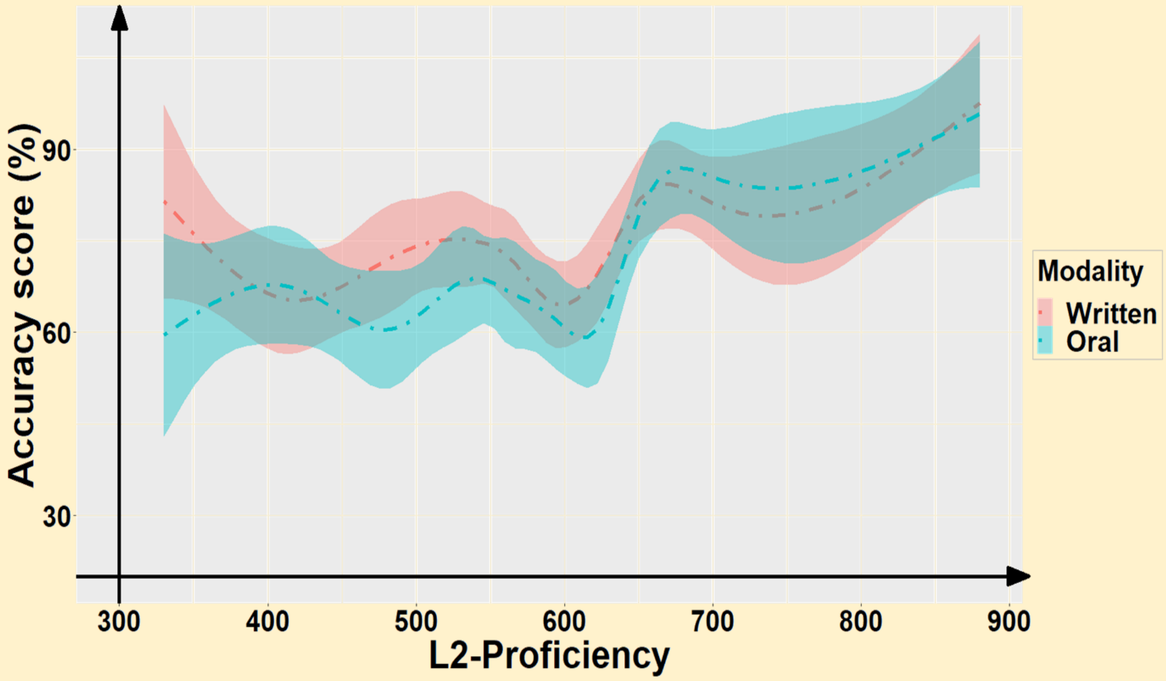

Figure 21. Accuracy score as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modality[40], the areas around are the 99% confidence intervals - Non-cognate task - French university students, dyslexic and typical-readers - Experiment 1.

The two-way interaction between Session and Group was also significant: accuracy scores being higher in Session 2 for typical-readers only, whereas accuracy scores decreased in Session 2 for dyslexic-readers. Finally, the three-way interaction between L2-Proficiency, Modality and Session was significant, with a Modality effect more important in Session 1 than in Session 2 for intermediate proficiency participants only, as displayed by Figure 22 page 108.

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[41], are reported in Table 10 page 108.

[40] Note on Figure 21 and 22 that both regression lines seemed somehow odd for the lowest proficiency participants, probably in relation to some noise, having more impact on word recognition among the lowest proficiency participants.

[41] Maximum BF = 6.029 * 10^15, corresponding to the same model formula than those of the final model of GLMM.

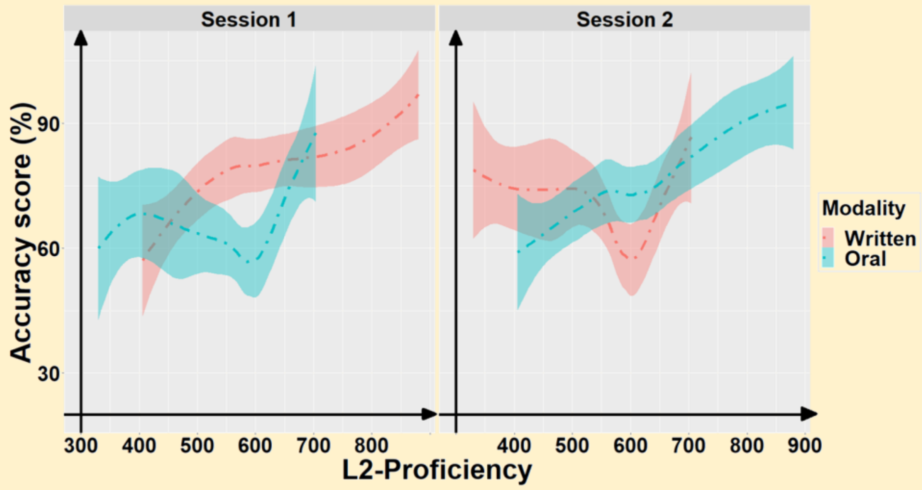

Figure 22. Accuracy score as a function of Session, Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modality, the areas around are the 99% confidence intervals - Non-cognate task - French university students, dyslexic and typical-readers, Experiment 1.

Table 10. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - Non-cognate task - French university students, typical and dyslexic-readers - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	1.40	.23	6.02	<.001*	**1.42**	**.26**	**[.93;1.93]**
L2-Proficiency (DL)	.34	.10	3.46	<.001*	**.35**	**.11**	**[.14;.57]**
Modality	-.35	.19	-1.90	.057	**-.35**	**.20**	**[-.76;.03]**
Session	-.06	.10	-.55	.580	**-.06**	**.10**	**[-.26;.14]**
Group	-.34	.23	-1.45	.146	**-.36**	**.26**	**[-.92;.15]**
L2Proficiency x Modality	.22	.10	2.28	<.05*	**-.15**	**.09**	**[-.33;.03]**
L2Proficiency x Session	-.15	.09	-1.66	.097	**.22**	**.10**	**[.03;.41]**
Session x Group	-.68	.20	-3.31	<.001*	**-.69**	**.21**	**[-1.10;-.27]**
Modality x Session	.91	.46	1.96	<.05*	**.93**	**.52**	**[-.11;1.94]**
L2Proficiency x Modality x Session	1.19	.41	2.90	<.01*	**1.22**	**.47**	**[.28;2.12]**

Note: Significant effects at a p < .05 level are marked with a ⁎. Final model formula: glmer(Response ~ Dialang_Level + Modality + Session + Group + Dialang_Level:Modality + Dialang_Level:Session + Session:Group + Modality:Session + Dialang_Level:Modality:Session + (1 | Participant) + (1 + Modality | Item), data = Data_response_words_Exp1bNCT_Frluniv_dysctrl, family = binomial)

4.3.2.2.Cognate task.

4.3.2.2.1.Discrimination rate (d'), cognate and non-cognate items.

Raw data are presented in Figure 23 page 109.

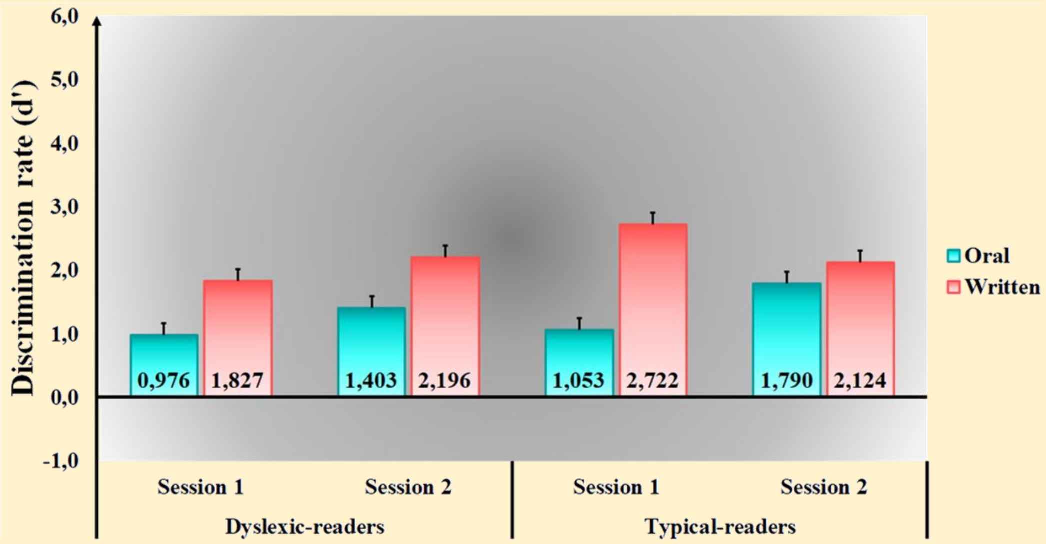

Figure 23. Raw data of d' - Cognate task - French university students, dyslexic and typical-readers - Experiment 1.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts[42], and Modality (written vs. oral), Session (1st vs. 2nd), Group (Dyslexic vs. Typical-readers), centred L2-Proficiency (DL out of 1,000), the two-way interactions between Modality and Session, Modality and Group, and Session and Group, and the three-way interaction between Modality, Session and Group as fixed effects (best model according to the AIC: $F(1,29) = 14.19$, $p < .01$). Those fixed effects explained 48% of the variance (marginal $R^2 = .483$).

Discrimination rates (d') were significantly lower in oral modality (1.323, SD = .73) than in written one (2.221, SD = .87), as well as in Session 1 (1.68, SD = 1.00) than in Session 2 (1.86, SD = .82). In addition, L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .29 of the d' of the participant, as displayed by Figure 24 page 110. Finally, the three-way interaction between Modality, Session and Group was significant. However, the Bayesian analysis demonstrated that the associated estimate was not different from zero.

[42] We could not include any random slope – according Modality or Session – because we had only one value of d' for each participant by Modality / Session.

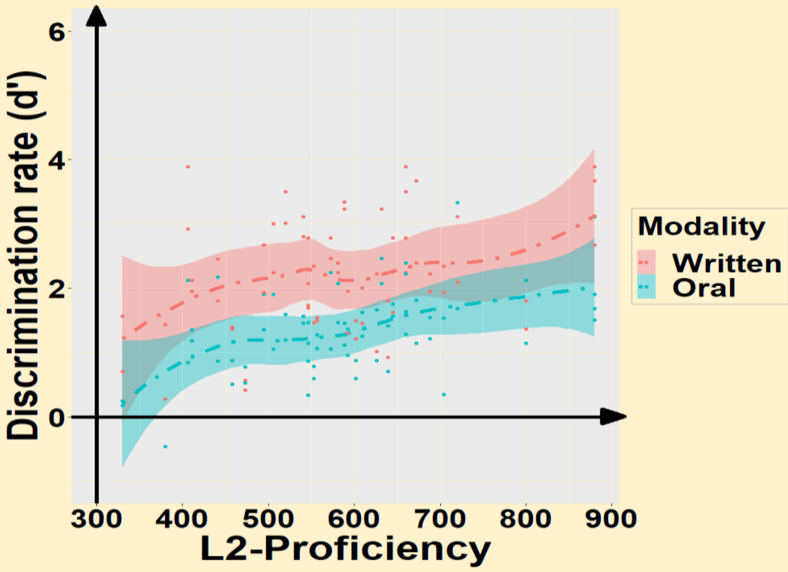

Figure 24. Discrimination rate as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modalities, the areas around are the 99% confidence intervals - Cognate task - French university students, dyslexic and typical-readers - Experiment 1

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[43], are reported in Table 11 below. Note that the estimate associated with the two-way interaction between Modality and Session seem different from zero: a session effect existing in oral modality ($t(60.112) = -3.539$, $p < .001$) but not in written one ($t(62.613) = .537$, $p = .593$).

Table 11. Parameter estimates of the final model fitted to the d' (**and output from the Bayesian analysis in bold**) - Cognate task - French university students, dyslexic and typical-readers - Experiment 1.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	1.77	.09	19.71	<.001*	**21.77**	**.10**	**[1.57;1.97]**
Modality	-.91	.09	-10.72	<.001*	**-.90**	**.09**	**[-1.07;-.73]**
Session	-.23	.09	2.75	<.01*	**-.26**	**.09**	**[-.43;-.09]**
L2-Proficiency (DL)	.29	.08	3.77	<.001*	**.26**	**.08**	**[.10;.42]**
Group	.28	.18	1.55	.132	**.31**	**.21**	**[-.09;.74]**
Modality x Session	.29	.38	.77	.451	**.34**	**.17**	**[.03;.67]**
Modality x Group	-.18	.17	-1.06	.249	**-.20**	**.17**	**[-.54;.14]**
Session x Group	-.33	.17	-1.94	.056	**.05**	**.17**	**[-.30;.40]**
Modality x Session x Group	1.96	.74	2.65	<.05*	**-.34**	**.33**	**[-1.02;.32]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(dprime ~ Modality + Session + Dialang_Level + Group + Modality:Session + Modality:Group + Session:Group + Modality;Session:Group + (1 | Participant), data = Data_dprime_Exp1bCT_Fruniv_dysctrl, REML = TRUE)

43 Maximum BF = 2.983 * 10^13, corresponding to the same model formula than those of the final model of LMM (bayes_R² = .72, SE = .03, 95% CrI = [0.65, 0.77]).

4.3.2.2.2. Accuracy scores (percentage of correct responses for word trials), cognate and non-cognate items.

Mean accuracy scores of our participants, on word trials only, according to Modality, Session, Cognateness and Group are presented in Figure 25 below.

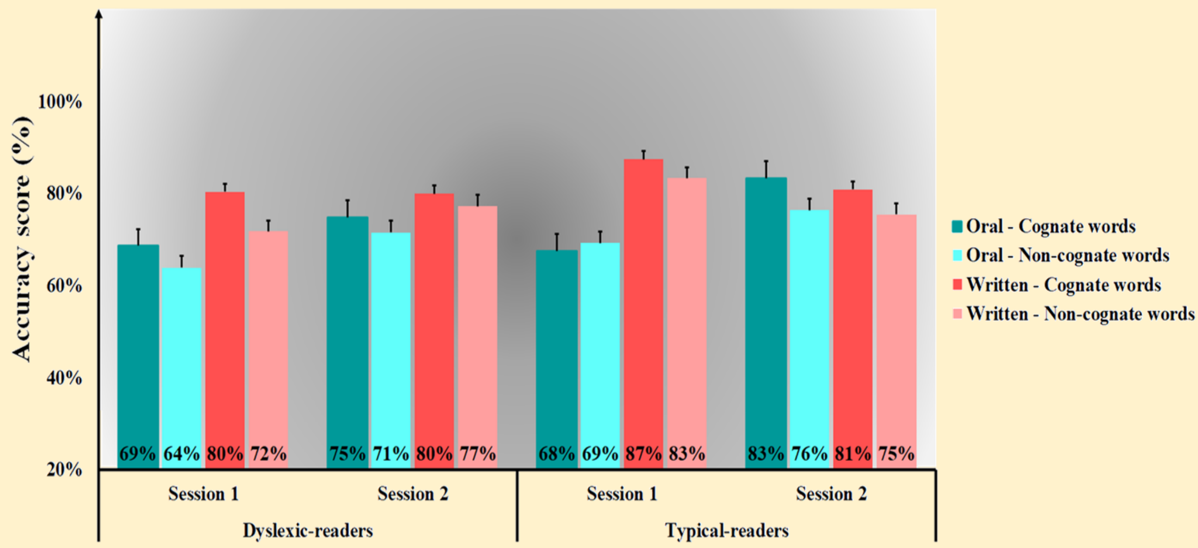

Figure 25. Raw data of Accuracy scores - Cognate task - French university students, dyslexic and typical-readers - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each word included by-participant random intercepts and by-item random intercepts and random slope considering the Modality, and Modality (written vs. oral), Session (1st vs. 2nd), L2-Proficiency (DL out of 1,000), Group (Dyslexic vs. Typical-readers), and Cognateness (Cognate vs. Non-cognate words), the two-way interactions between L2-Proficiency and Modality, Group and Modality, Group and Session, and Modality and Session, and the three-way interaction between Group, Modality and Session as fixed effects (best model according to the AIC: $\chi^2 = 8.07$, $p < .01$). Those fixed and random effects explain 29% of the variance (adjusted $R^2 = .287$).

Accuracy scores were significantly lower in oral modality (74%, SD = 44) than in written one (82%, SD = 39). L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .55 of the mean accuracy of the participant. Moreover, the three-way interaction between Group, Modality and Session was significant, a session effect existing in oral modality for typical-readers only. Finally, the two-way interaction between L2-Proficiency and Modality was significant, modality effect (*i.e.*, the difference in accuracy scores between modalities) being of higher amplitude for participants from lower proficiency than for those from higher proficiency, as displayed by Figure 26 below[44].

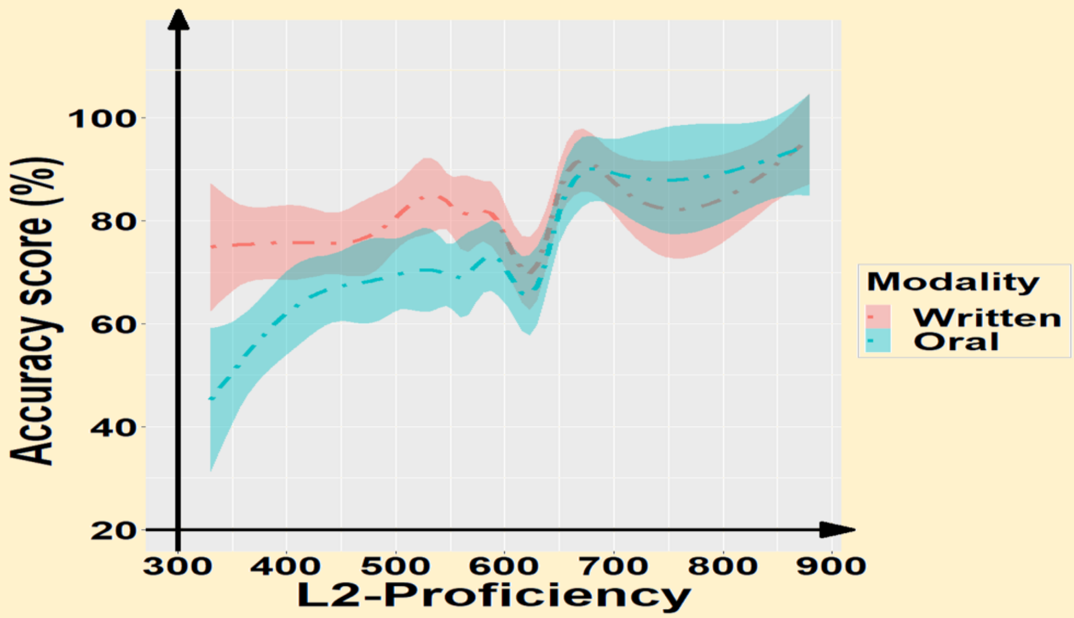

Figure 26. Accuracy score as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modality, the areas around are the 99% confidence intervals - Cognate task - French university students, dyslexic and typical-readers - Experiment 1.

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[45], are reported in Table 12 page 113. Cognateness effect was non-significant in the model including the interactions, while raw data suggest an effect. We thus performed post-hoc analysis to compare the mean accuracy scores of our independent groups according to Cognateness. They showed that there was a cognate effect with higher accuracy scores for cognate words (81%, SD = 40) than non-cognate words (75%, SD = 43, t(3903.4 = 3.987, p < .001).

[44] Note on Figure 17 that the regression lines seemed somehow odd for the participants with intermediate proficiency, probably in relation to some noise, having more impact on word recognition among those participants.
[45] Maximum BF = 1.085 * 10^38, corresponding to the same model formula than those of the final model of GLMM.

Table 12. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - Cognate task - French university students, typical and dyslexic-readers - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	1.86	.20	9.45	<.001*	**1.89**	**.22**	**[1.46;2.32]**
L2-Proficiency (DL)	.55	.10	5.83	<.001*	**.56**	**.11**	**[.35;.78]**
Group	.37	.21	1.73	.084	**.37**	**.26**	**[-.12;.89]**
Modality	-.73	.17	-4.18	<.001*	**-.74**	**.18**	**[-1.12;-.38]**
Session	.16	.09	1.69	.090	**.16**	**.09**	**[-.03;.34]**
Cognateness	-.25	.33	-.76	.445	**-.26**	**.36**	**[-.97;.44]**
L2-Proficiency x Modality	.24	.09	2.70	<.01*	**.24**	**.09**	**[.06;.41]**
Group x Modality	-.14	.18	-.78	.437	**-.14**	**.18**	**[-.49;.20]**
Group x Session	-.12	.19	-.65	.518	**-.12**	**.20**	**[-.51;.26]**
Modality x Session	.15	.44	.33	.740	**.15**	**.50**	**[-.88;1.10]**
Group x Modality x Session	2.73	.88	3.10	<.01*	**2.73**	**1.02**	**[.73;4.71]**

Note: Significant effects at a p < .05 level are marked with a ∗*. Final model formula: glmer(Response ~ Dialang_Level + Group + Modality + Session + Cognateness + Dialang_Level:Modality + Group:Modality + Group:Session + Modality:Session + Group:Modality:Session + (1 | Participant) + (1 + Modality | Item), data = Data_response_words_Exp1bCT_Fruniv_dysctrl, family = binomial)*

4.3.2.2.3.Accuracy scores (percentage of correct responses for word trials), cognate items only.

As previously, we performed the same analyses (for accuracy) but including only cognate words. Mean accuracy scores of our participants, on cognate word trials only, according to Modality, Session, Cognate-type and Group are presented in Figure 27 below.

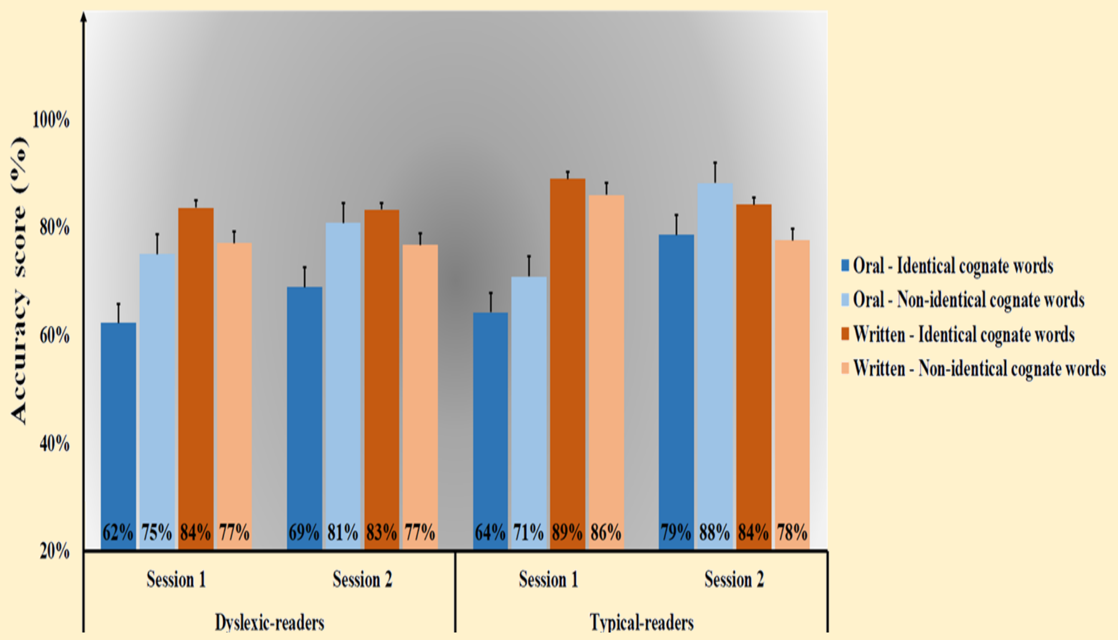

Figure 27. Raw data of Accuracy scores - Cognate task, cognate items only - French university students, dyslexic and typical-readers - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each cognate word included by-participant and by-item random intercepts, and L2-Proficiency (DL out of 1,000), Cognate-type (identical vs. non-identical), Session (1st vs. 2nd), Modality (written vs. oral), Group (Dyslexic vs. Typical-readers), the two-way interactions between L2-Proficiency and Modality, Cognate-type and Modality, Session and Modality, L2-Proficiency and Group, Session and Group, Modality and Group, and the three-way interaction between Session, Modality and Group as fixed effects (best model according to the AIC: $\chi^2 = 8.462$, $p < .01$). Those fixed and random effects explain 26% of the variance (adjusted $R^2 = .262$).

Accuracy scores were significantly lower in oral modality (76%, SD = 43) than in written one (85%, SD = 36), and for dyslexic-readers (78%, SD = 41) than for typical-readers (83%, SD = 38). Interestingly, the interaction between Modality and Group was also significant, modality effect (*i.e.*, the difference in accuracy scores between modalities) being more important for dyslexic-readers than typical-readers. Moreover, the three-way interaction between Session, Modality and Group was significant, typical-readers presenting a ceiling effect in Session 2, and modality effect being more important for dyslexic-readers than typical-readers, in Session 1, but not in Session 2.

Note that the two-way interaction between Modality and Cognate-type was significant: accuracy scores being higher for non-identical cognate words (79%, SD = 41) than for identical cognate words (73%, SD = 45) in oral modality ($t(958.75) = 2.266$, $p < .05$), whereas accuracy scores were higher for identical cognate words (91%, SD = 41) than non-identical cognate words (79%, SD = 29) in written modality ($t(919.93) = -5.173$, $p < .001$, explaining why the Bayesian analysis demonstrated that the estimate associated with Cognate-type was not different from zero. By the way, post-hoc analyses demonstrated that Cognate-type effect was marginally non-significant, accuracy scores seeming to be lower for non-identical cognate words (79%, SD = 41) than for identical cognate words (82%, SD = 39, $t(1966.2) = -1.491$, $p = .068$).

Note also that L2-Proficiency effect was significant, as well as the two-way interaction between L2-Proficiency and Modality, an increase of DL score of 100 out of 1,000 resulting in an increase of .43 of the mean accuracy of the participant, and modality effect existing for lower proficiency participants only, as displayed by Figure 28 below.

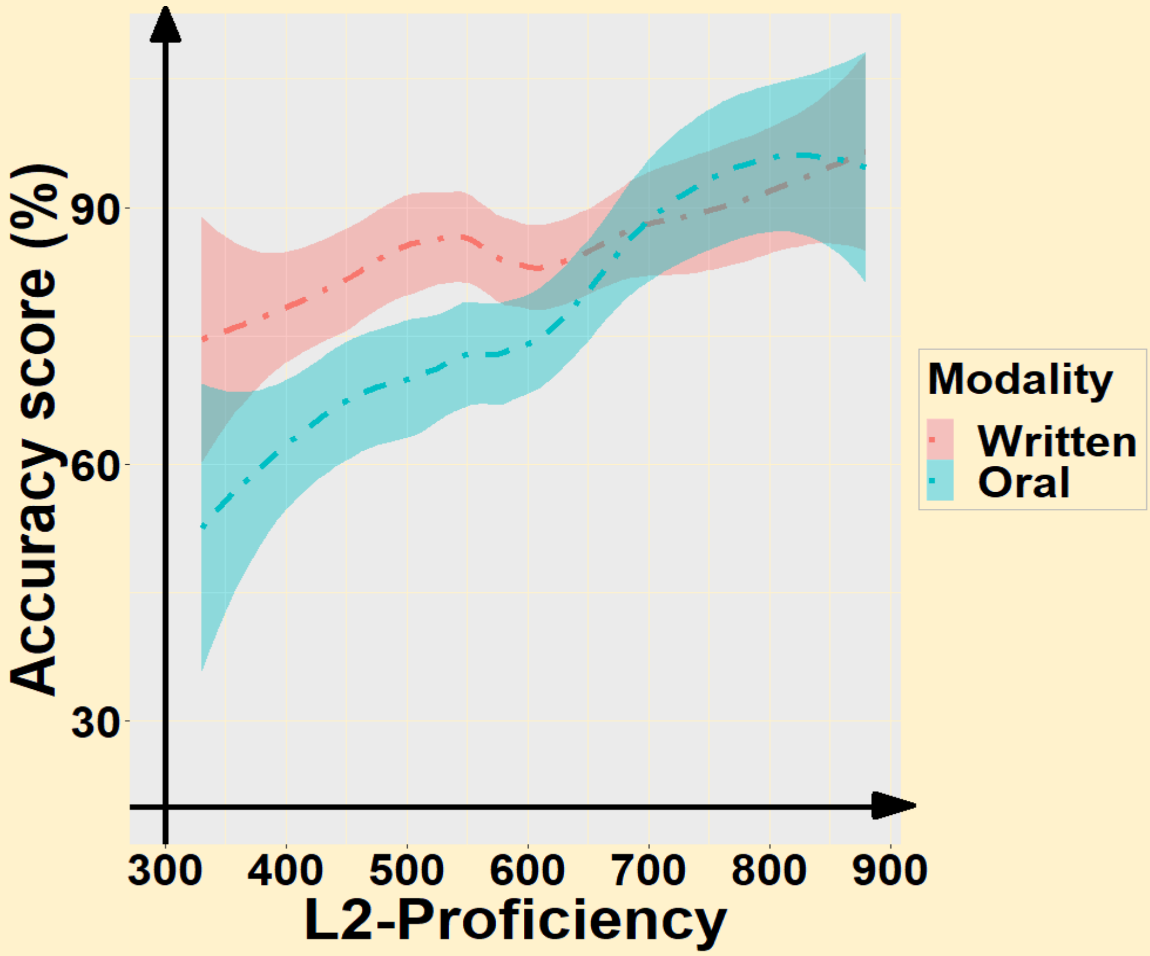

Figure 28. Accuracy score as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modality, the areas around are the 99% confidence intervals - Cognate task, cognate items only - French university students, dyslexic and typical-readers - Experiment 1.

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[46], are reported in Table 13 page 116.

[46] Maximum BF = 1.092 * 10^22, corresponding to the same model formula than those of the final model of GLMM.

Table 13. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - Cognate task, cognate items only - French university students, typical and dyslexic-readers - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	-.41	1.12	-.37	.715	**-.35**	**1.30**	**[-2.96;2.32]**
L2-Proficiency (DL)	.44	.16	2.80	<.01*	**.43**	**.18**	**[.09;.79]**
Cognate-type	.90	.44	2.06	<.05*	**.90**	**.50**	**[-.12;1.90]**
Session	.59	.44	1.35	.179	**.53**	**.48**	**[-.46;1.46]**
Modality	3.69	.78	4.73	<.001*	**3.68**	**.84**	**[2.04;5.27]**
Group	1.02	.41	2.52	<.05*	**1.01**	**.45**	**[.14;1.89]**
L2-Proficiency x Modality	.28	.13	2.19	<.05*	**.28**	**.13**	**[.03;.54]**
Modality x Cognate-type	-1.52	.27	-5.60	<.001*	**-1.54**	**.28**	**[-2.10;-.99]**
Session x Modality	-1.09	.75	-1.45	.147	**-.99**	**.87**	**[-2.68;.77]**
L2-Proficiency x Group	-.10	.22	-.46	.644	**-.08**	**.25**	**[-.57;.45]**
Session x Group	-1.34	.60	-2.23	<.05*	**-1.28**	**.66**	**[-2.57;.05]**
Modality x Group	-1.68	.57	-2.94	<.01*	**-1.63**	**.64**	**[-2.88;-.36]**
Session x Modality x Group	3.15	1.02	3.09	<.01*	**3.06**	**1.17**	**[.70;5.43]**

*Note: Significant effects at a p < .05 level are marked with a *. Final model formula: glmer(Response ~ Dialang_Level + Cognate_type + Session + Modality + Group + Dialang_Level:Modality + Modality:Cognate_type + Session:Modality + Dialang_Level:Group + Session:Group + Modality:Group + Session:Modality:Group + (1 | Participant) + (1 | Item), data = Data_response_cognate_words_Exp1bCT_Fruniv_dysctrl, family = binomial)*

4.3.2.2.4.Summary of the results.

Table 14 below presents a summary of the results of Experiment 1 among French typical and dyslexic university students. The aim being to compare typical and dyslexic-readers, main results concerned group effect and its interaction with other factors.

Table 14. Summary of the results of Experiment 1 - French university students, dyslexic and typical-readers.
(M = Modality, S = Session, P = L2 Proficiency, C = Cognateness, CT = Cognate-type, G = Group, ✓ = significant effect, ✗ = non-significant effect, ± = marginally non-significant effect)

Task / Analysis	Dependent Variable	M	G	P	S	C/CT	G:S	M:S	P:M	P:M:S	M:G	G:M:S	M:C/CT
Non-cognate task	d’	✓	✗	✓	✗	NA	✗	✗	✗	✗	✗	✗	NA
	Accuracy	✗	✗	✓	✗	NA	✓	✗	✓	✓	✗	✗	NA
Cognate task / all stimuli	d’	✓	✗	✓	✓	NA	✗	✓	✗	✗	✗	✓	NA
	Accuracy	✓	✗	✓	✗	✓	✗	✗	✓	✗	✗	✓	✗
Cognate task / cognate stimuli	Accuracy	✓	✓	✓	✗	±	✗	✗	✓	✗	✓	✓	✓

4.3.3.French typical-reader middle-school students.

4.3.3.1.Non-cognate task.

We excluded one participant from the analyses, due to his/her high pseudoword error rate. In order to be able to compare the results between the cognate and the non-cognate tasks, we excluded also five other participants[47] who needed to be excluded from the cognate task. Finally, we included a remaining Oral-Written-TypFrMid group of 20 participants and a remaining Written-Oral-TypFrMid group of 22 participants.

4.3.3.1.1.Discrimination rate (d').

Raw data are presented in Figure 29 below.

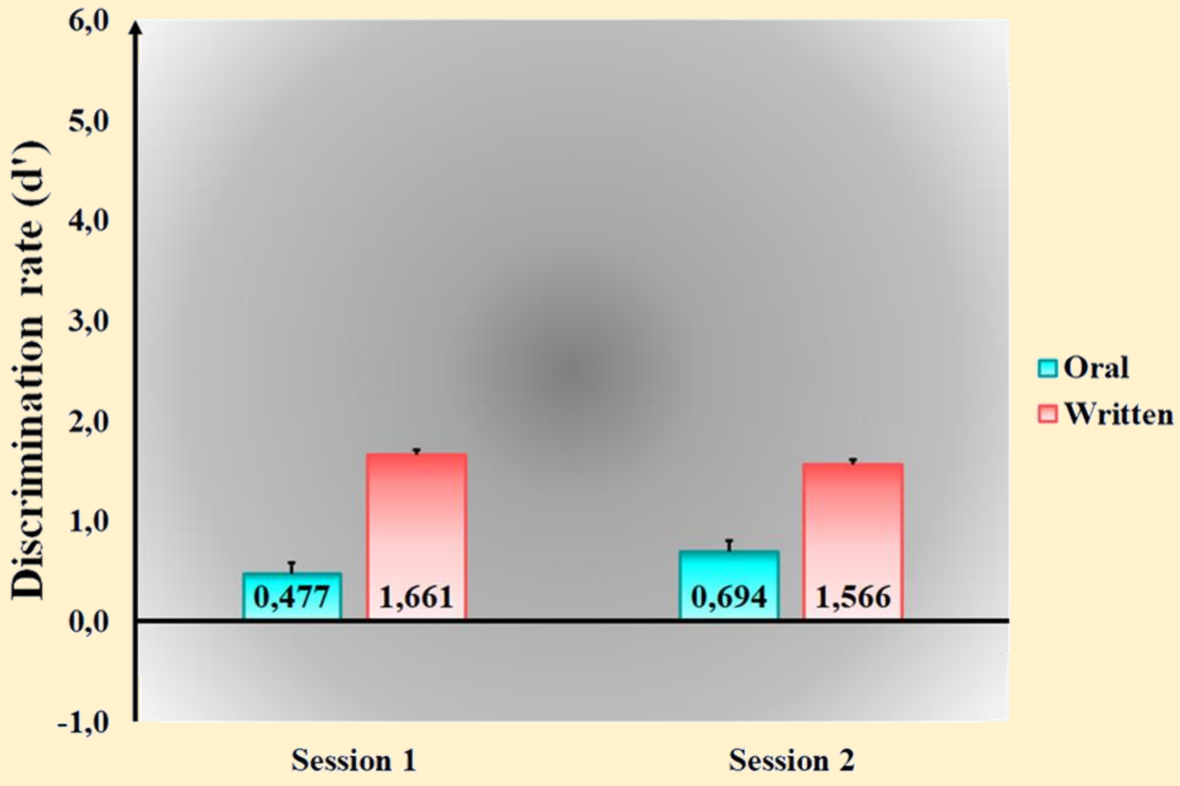

Figure 29. Raw data of d' - Non-cognate task - French typical-reader middle-school students - Experiment 1.

[47] We performed also the analysis, without the exclusion of those participants. The results were similar to those described in this section.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts[48], and Modality (written vs. oral), and centred L2-Proficiency (DL out of 1,000) as fixed effects (best model according to the AIC: $F(1,47) = 30.55$, $p < .001$). Those fixed effects explained 63% of the variance (marginal $R^2 = .633$).

Discrimination rates (d') were significantly lower in oral modality (.590, SD = .617) than in written one (1.615, SD = .728). In addition, L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .23 of the d' of the participant, as displayed by Figure 30 below.

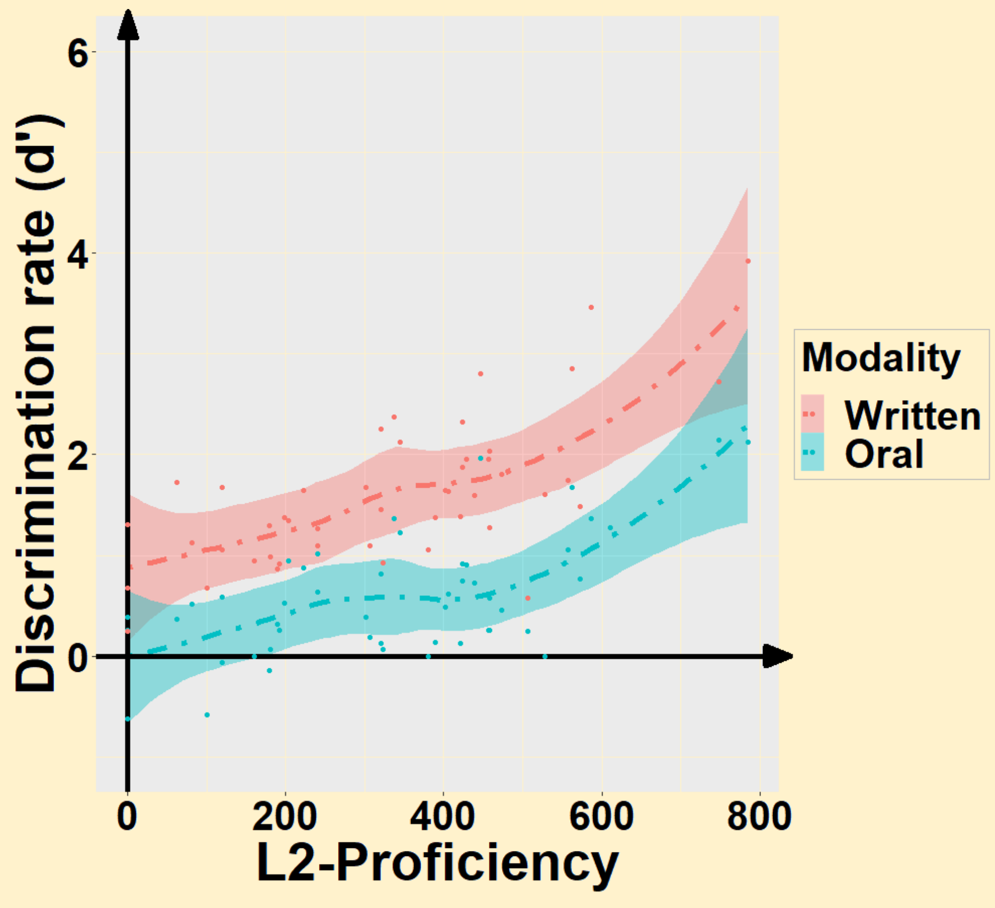

Figure 30. Discrimination rate as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modalities, the areas around are the 99% confidence intervals - Non-cognate task - French typical-reader middle-school students - Experiment 1.

[48] We could not include any random slope – according Modality or Session – because we had only one value of d' for each participant by Modality / Session.

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[49], are reported in Table 15 below.

Table 15. Parameter estimates of the final model fitted to the d' (**and output from the Bayesian analysis in bold**) - Non-cognate task - French typical-reader middle-school students - Experiment 1.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	1.62	.07	21.72	<.001*	**1.61**	**.08**	**[1.46;1.76]**
Modality	-1.03	.06	-17.29	<.001*	**-1.03**	**.06**	**[-1.15;-.90]**
L2-Proficiency (DL)	.23	.04	6.40	<.001*	**.23**	**.04**	**[.16 ;.31]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(dprime ~ Modality + Dialang_Level + (1 | Participant), data = Data_dprime_Exp1b_NCT_Fruniv_dysctrl, REML = TRUE)

4.3.3.1.2.Accuracy scores (percentage of correct responses for word trials).

Mean accuracy scores of our participants, on word trials only, according to Modality and Session are presented in Figure 31 below.

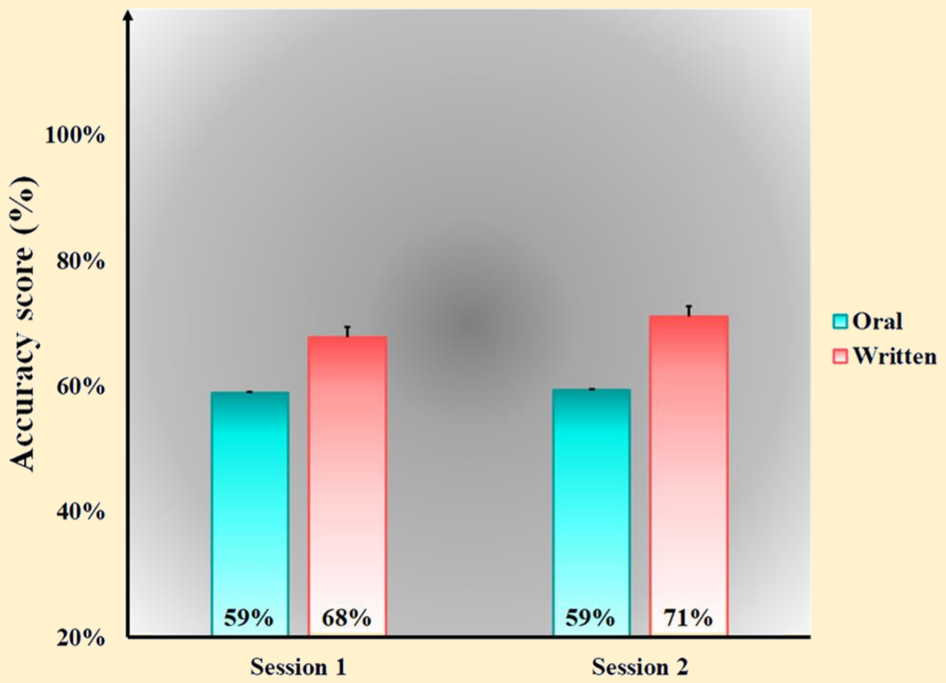

Figure 31. Raw data of Accuracy scores - Non-cognate task - French typical-reader middle-school students - Experiment 1.

[49] Maximum BF = 1.087 * 10^18, corresponding to the same model formula than those of the final model of LMM (bayes_R² = .88, SE = .02, 95% CrI = [.83, .91]).

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each word included by-participant and by-item random intercepts and random slopes considering the Modality, and centred L2-Proficiency (DL out of 1,000) and Modality (written vs. oral) as fixed effects (best model according to the AIC: $\chi^2 = 19.19$, $p < .001$). Those fixed and random effects explain 29% of the variance (adjusted $R^2 = .292$).

Accuracy scores were significantly lower in oral modality (59%, SD = 49) than in written modality (69%, SD = 46). In addition, L2-Proficiency effect was significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .32 of the mean accuracy of the participant as displayed by Figure 32 below[50].

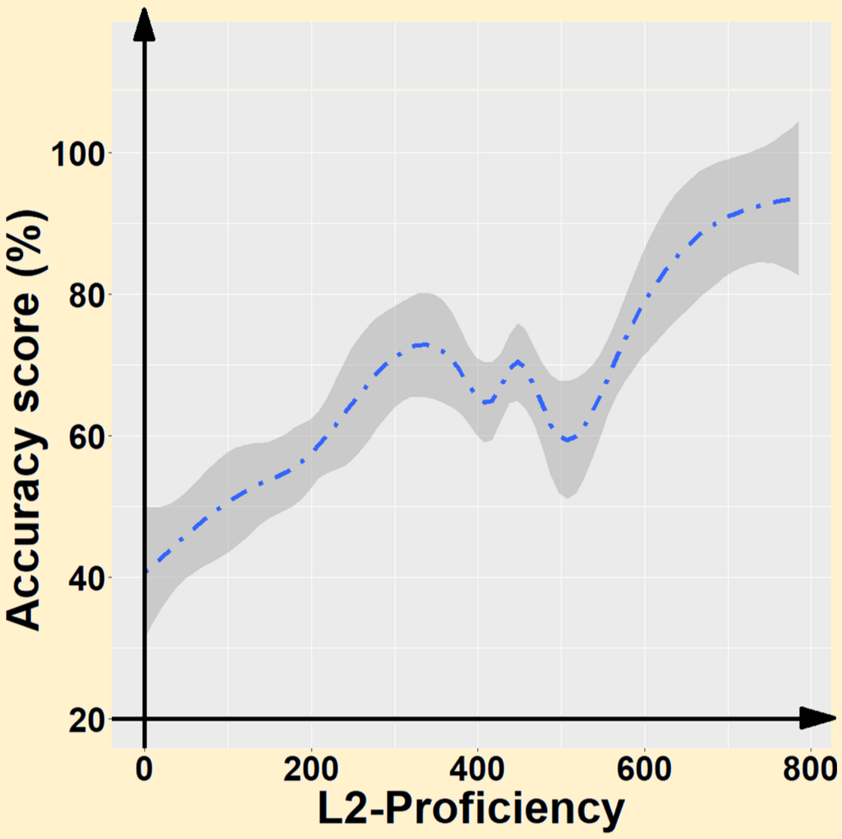

Figure 32. Accuracy score as a function of Dialang score (out of 1,000): dotdashed line is the regression line, the area around is the 99% confidence interval - Non-cognate task - French typical-reader middle-school students - Experiment 1.

[50] Note on Figure 32 that the regression line seemed somehow odd, mostly for intermediate proficiency participants, probably in relation to some noise, having more impact on word recognition among those participants.

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[51], are reported in Table 16 below.

Table 16. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - Non-cognate task - French typical-reader middle-school students - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	1.25	.28	4.45	<.001*	**1.22**	**.30**	**[.62;1.81]**
Modality	-.81	.20	-4.16	<.001*	**-.79**	**.21**	**[-1.20;-.39]**
L2-Proficiency (DL)	.32	.07	4.88	<.001*	**.33**	**.07**	**[.19;.47]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(Response ~ Dialang_Level + Modality + (1 + Modality | Participant) + (1 + Modality | Item), data = Data_response_words_Exp1cNCT_Frcoll_ctr, family = binomial)

4.3.3.2.Cognate task

We excluded the same six participants[52] as for the non-cognate task from the analyses, due to their high pseudoword error rates.

4.3.3.2.1.Discrimination rate (d'), cognate and non-cognate items.

Raw data are presented in Figure 33 page 122.

[51] Maximum BF = 4.864 * 10^37, corresponding to the same model formula than those of the final model of GLMM.

[52] As previously, we performed the same analyses, without the exclusion of those participants. The pattern of results was identical.

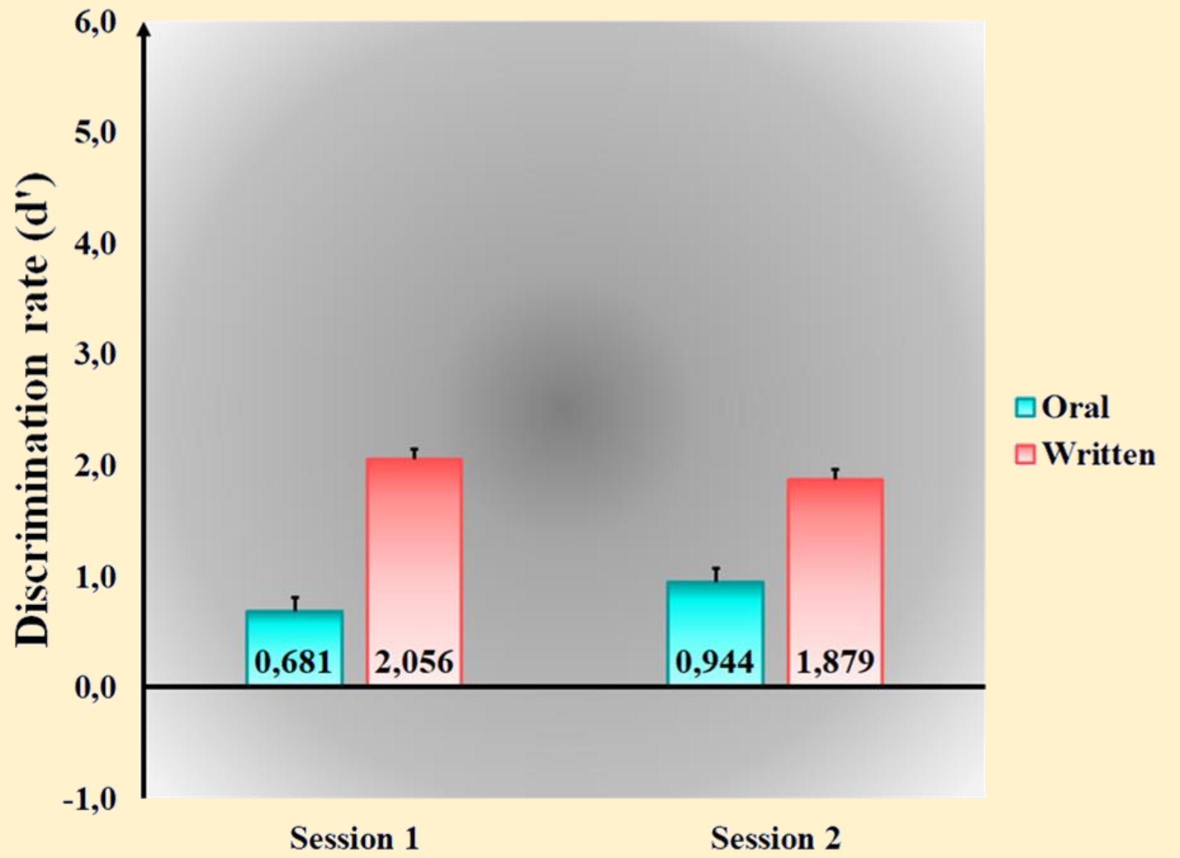

Figure 33. Raw data of d' - Cognate task - French typical-reader middle-school students - Experiment 1.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts, and Modality (written vs. oral), centred L2-Proficiency (DL out of 1,000) as fixed effects (best model according to the AIC: $F(1,47) = 30.55$, $p < .001$). Those fixed effects explained 63% of the variance (marginal $R^2 = .633$).

Discrimination rates (d') were significantly lower in oral modality (.59, SD = .62) than in written one (1.62, SD = .73). In addition, L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .23 of the d' of the participant, as displayed by Figure 34 page 123.

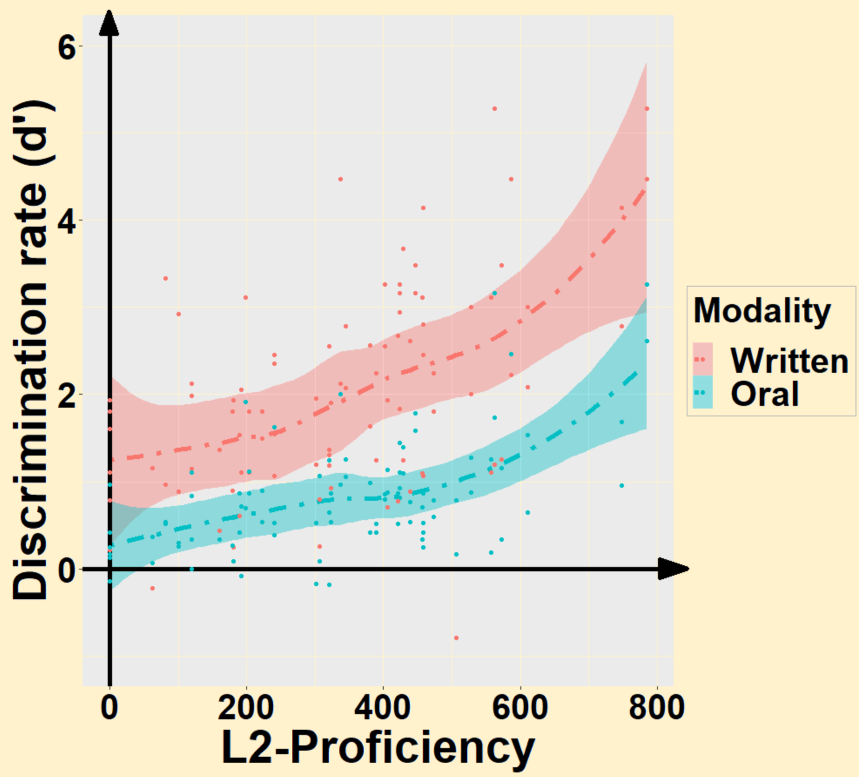

Figure 34. Discrimination rate as a function of Dialang score (out of 1,000) and Modality: dotdashed lines are the regression lines according to Modalities, the areas around are the 99% confidence intervals - Cognate task - French typical-reader middle-school students - Experiment 1

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[53], are reported in Table 17 below.

Table 17. Parameter estimates of the final model fitted to the d' (**and output from the Bayesian analysis in bold**) - Cognate task - French typical-reader middle-school students - Experiment 1.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	1.62	.07	21.72	<.001*	**1.61**	**.08**	**[1.46;1.77]**
Modality	-.1.03	.06	-17.29	<.001*	**-1.03**	**.06**	**[-1.15;-.90]**
L2-Proficiency (DL)	.23	.04	6.40	.<.001*	**.23**	**.04**	**[.16;.31]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(dprime ~ Modality + Dialang_Level + (1 | Participant), data = Data_dprime_Exp1cCT_Frcoll_ctr, REML = TRUE)

[53] Maximum BF = 1.067 * 10^18, corresponding to the same model formula than those of the final model of LMM (bayes_R² = .88, SE = .02, 95% CrI = [.83; .91]).

4.3.3.2.2.Accuracy scores (percentage of correct responses for word trials), cognate and non-cognate items.

Mean accuracy scores of our participants, on word trials only, according to Modality, Session and Cognateness are presented in Figure 35 below.

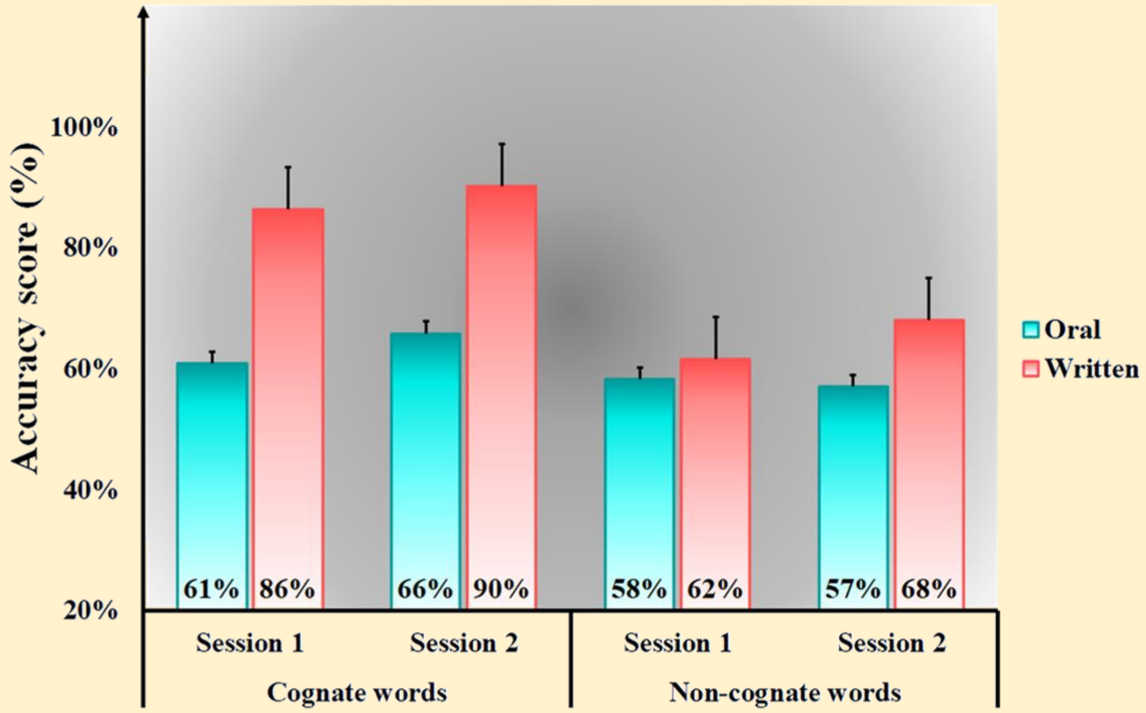

Figure 35. Raw data of Accuracy scores - Cognate task - French typical-reader middle-school students - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each word included by-participant and by-item random intercepts, and Modality (written vs. oral), Session (1st vs. 2nd), L2-Proficiency (DL out of 1,000), Cognateness (Cognate vs. Non-cognate words) and the two-way interactions between Modality and Session, and between Modality and Cognateness as fixed effects (best model according to the AIC: $\chi^2 = 83.36$, $p < .001$). Those fixed and random effects explain 26% of the variance (adjusted $R^2 = .264$).

Accuracy scores were significantly lower in oral modality (61%, SD = 49) than in written one (76%, SD = 43), and for non-cognate words (61%, SD = 49) than for cognate words

(76%, SD = 43). L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .21 of the mean accuracy of the participant. Finally, the two-way interaction between Modality and Cognateness was significant, cognate effect (*i.e.*, the difference in accuracy scores between cognate and non-cognate words) being larger in written modality than in oral one.

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[54], are reported in Table 18 below.

Table 18. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - Cognate task - French typical-reader middle-school students - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	2.15	.24	9.12	<.001*	**2.17**	**.26**	**[1.65;2.66]**
Modality	-1.45	.25	-5.78	<.001*	**-1.46**	**.27**	**[-2.00;-.94]**
L2-Proficiency (DL)	.21	.06	3.45	<.01*	**.21**	**.06**	**[.08;.33]**
Session	.49	.24	2.04	.399	**.50**	**.26**	**[-.02;1.00]**
Cognateness	-1.59	.24	-6.51	<.001*	**-1.60**	**.25**	**[-2.09;-1.12]**
Modality x Session	-.50	.45	-1.11	.874	**-.51**	**.49**	**[-1.46;.47]**
Modality x Cognateness	1.31	.15	9.00	<.001*	**1.32**	**.15**	**[1.04;1.61]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(Response ~ Modality + Dialang_Level + Session + Cognateness + Modality:Session +Modality:Cognateness+ (1 | Participant) + (1 | Item), data = Data_response_words_Exp1cCT_Frcoll_ctr, family = binomial)

We will now present additional analysis concerning cognate items only.

[54] Maximum BF = 3.905 * 10^82, corresponding to the same model formula than those of the final model of GLMM.

4.3.3.2.3.Accuracy scores (percentage of correct responses for word trials), cognate items only.

As previously, we performed the same analyses (for accuracy) but including only cognate words[55]. Mean accuracy scores of our participants, on cognate word trials only, according to Modality, Session and Cognate-type are presented in Figure 36 below.

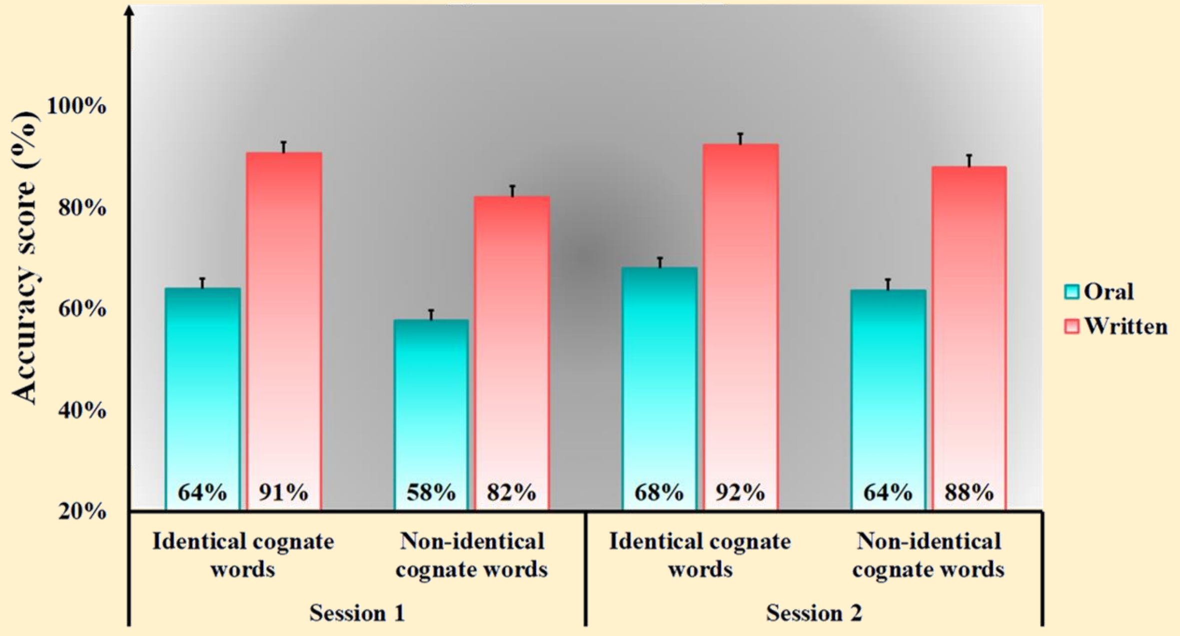

Figure 36. Raw data of Accuracy scores on cognate word trials only - Cognate task - French typical-reader middle-school students - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each cognate word included by-participant and by-item random intercepts, and L2-Proficiency (DL out of 1,000), Modality (written vs. oral), Session (1st vs. 2nd), Cognate-type (identical vs. non-identical), and the two-way interactions between L2-Proficiency and Cognate-type as fixed effects (best model according to the AIC: $\chi^2 = 13.531$, $p < .001$). Those fixed and random effects explain 24% of the variance (adjusted $R^2 = .240$).

[55] Likewise, we performed also additional analysis, similar to that of the non-cognate task, in order to replicate our results and to determine the impact of cognate words included into the lists of stimuli on L2 non-cognate word recognition. The results were similar to those of the non-cognate task.

Accuracy scores were significantly lower in oral modality (63%, SD = 48) than in written one (88%, SD = 32), and in Session 2 (77%, SD = 42) than in Session 1 (74%, SD = 44). In addition, L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .73 of the mean accuracy of the participant. Finally, the two-way interaction between L2-Proficiency and Cognate-type was significant, L2-Proficiency effect existing for non-identical cognate words but not for identical cognate words, as displayed by Figure 37 below[56].

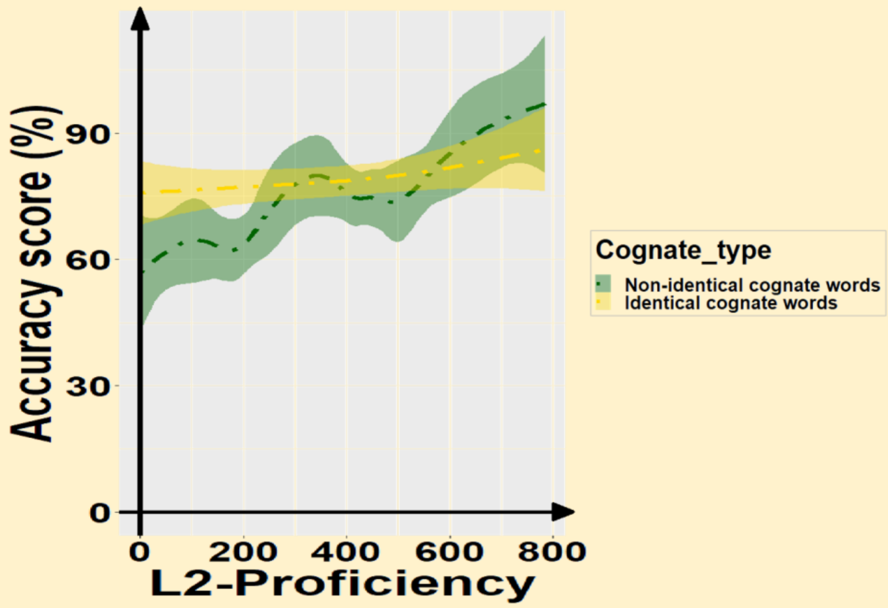

Figure 37. Accuracy score as a function of Dialang score (out of 1,000) and Cognate-type: dotdashed lines are the regression lines according to Cognate-type, the areas around are the 99% confidence intervals - Cognate task, cognate words only - French typical-reader middle-school students - Experiment 1.

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[57], are reported in Table 19 page 128.

[56] Note on Figure 37 that the regression line seemed somehow odd for non-identical cognate words, probably in relation to some noise, having more impact on this particular category of items.

[57] Maximum BF = 4.853 * 10^57, corresponding to the same model formula than those of the final model of GLMM.

Table 19. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) on cognate words - Cognate task - French typical-reader middle-school students - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	1.38	.69	8.27	<.001*	**1.36**	**.77**	**[-.16;2.95]**
L2-Proficiency (DL)	.73	.16	4.70	<.001*	**.74**	**.16**	**[.43;1.06]**
Modality	-1.70	.12	-14.72	<.001*	**-1.71**	**.12**	**[-1.94;-1.49]**
Session	.32	.11	2.86	<.05*	**.32**	**.11**	**[.10;.55]**
Cognate-type	.33	.27	1.23	.225	**.34**	**.30**	**[-.27;.93]**
L2-Proficiency x Cognate-type	-.21	.06	-3.68	<.01*	**-.22**	**.06**	**[-.33;-.10]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(Response ~ Dialang_Level + Modality + Session + Cognate_type + Dialang_Level: Cognate_type + (1 | Participant) + (1 | Item), data = Data_response_cognate_words_Exp1cCT_Frcoll_ctr, family = binomial)

4.3.3.2.4.Summary of the results.

Table 20 below presents a summary of the main results of both the non-cognate and the cognate task among French typical-reader middle-school students.

Table 20. Summary of the results of Experiment 1 - French typical-reader middle-school students.

(M = Modality, S = Session, P = L2 Proficiency, C = Cognateness, CT = Cognate-type, ✓ = significant effect, ✗ = non-significant effect)

Task / Analysis	Dependent Variable	M	S	P	C / CT	M:S	C/CT:M	CT:P	S:P
Non-cognate task	d’	✓	✗	✓	NA	✗	NA	NA	✗
	Accuracy	✓	✗	✓	NA	✗	NA	NA	✗
Cognate task / all stimuli	d’	✓	✗	✓	NA	✗	NA	NA	✗
	Accuracy	✓	✗	✓	✓	✗	✓	NA	✗
Cognate task / cognate stimuli	Accuracy	✓	✓	✓	✓	✗	✗	✓	✗

4.3.4.French typical and dyslexic-reader middle-school students.

4.3.4.1.Non-cognate task.

4.3.4.1.1.Discrimination rate (d’).

Raw data are presented in Figure 38 page 129.

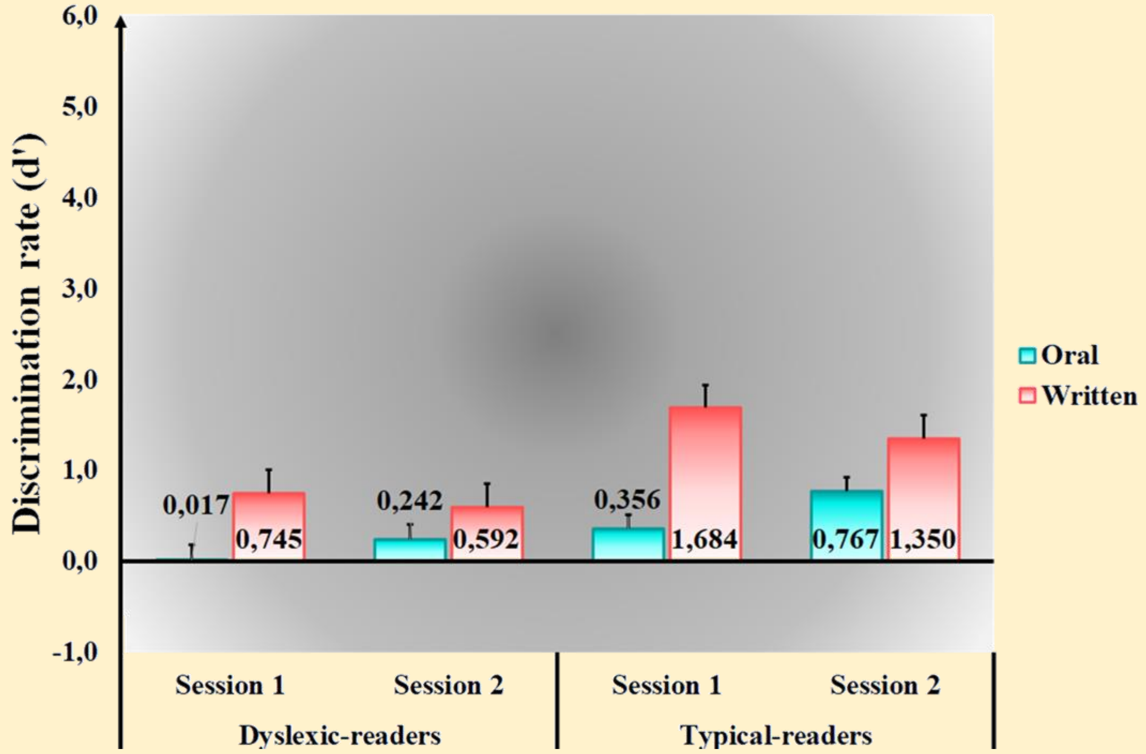

Figure 38. Raw data of d' - Non-cognate task - French middle-school students, dyslexic and typical-readers - Experiment 1.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts[58], and Modality (written *vs*. oral), Session (1st *vs*. 2nd), centred L2-Proficiency (DL out of 1,000), Group (Dyslexic *vs*. Typical-readers), the two-way interactions between Modality and Session, Modality and L2-Proficiency, Session and L2-Proficiency, and Modality and Group, and the three-way interaction between Modality, Session and L2-Proficiency as fixed effects (best model according to the AIC: $F(1,29) = 7.09$, $p < .05$). Those fixed effects explained 75% of the variance (marginal $R^2 = .745$).

Discrimination rates (d') were significantly lower in oral modality (.336, SD = .427) than in written one (1.085, SD = .588) and for dyslexic-readers (.393, SD = .471) than for typical-readers (1.028, SD = .623). In addition, L2-Proficiency effect was significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .08 of the d' of the

[58] We could not include any random slope – according Modality or Session – because we had only one value of d' for each participant by Modality / Session.

participant, as displayed by Figure 39 below. Moreover, the two-way interaction between Modality and Session was significant, d' being higher in Session 2 in the oral modality but not in the written one. That between Modality and Group was also significant, the modality effect – *i.e.*, the difference in d' between modalities – being higher for typical-readers than dyslexic-readers. Finally, the three-way interaction between Modality, Session and L2-Proficiency was significant, the modality effect being more important for intermediate proficiency bilinguals in Session 1, but not in Session 2, as displayed by Figure 40 page 131.

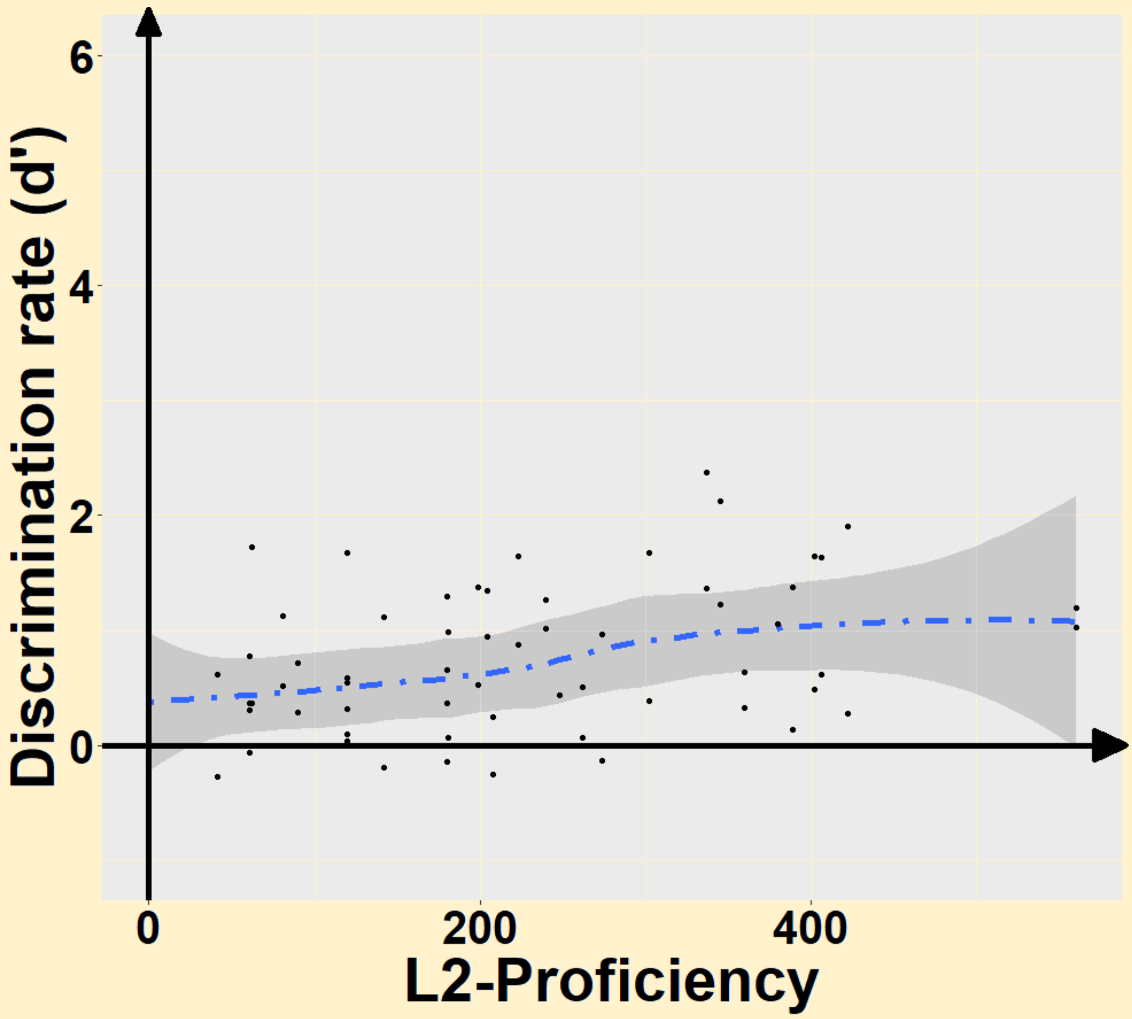

Figure 39. Discrimination rate as a function of Dialang score (out of 1,000): dotdashed line is the regression line, the area around is the 99% confidence interval - Non-cognate task - French middle-school students, dyslexic and typical-readers - Experiment 1

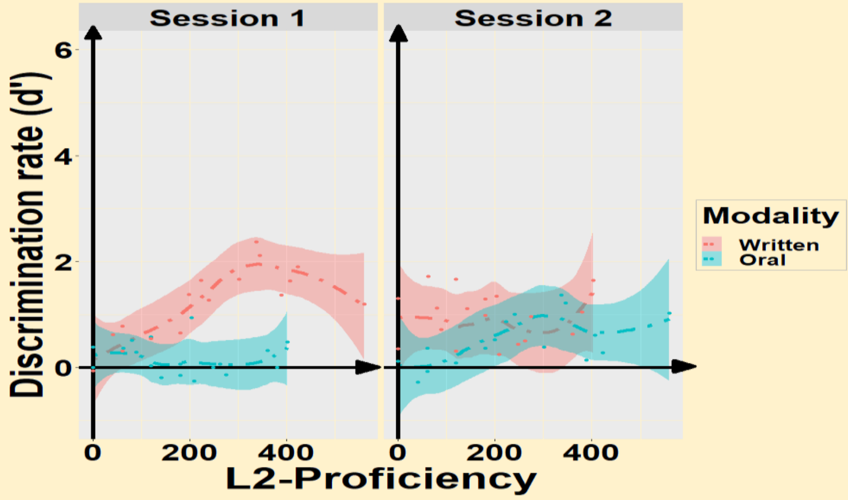

Figure 40. Discrimination rate as a function of Dialang score (out of 1,000), Modality and Session: dotdashed lines are the regression lines according to Modality, the areas around are the 99% confidence intervals - Non-cognate task - French middle-school students, dyslexic and typical-readers - Experiment 1.

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[59], are reported in Table 21 below.

Table 21. Parameter estimates of the best model fitted to the d' (**and output from the Bayesian analysis in bold**) - Non-cognate task - French middle-school students, dyslexic and typical-readers - Experiment 1.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	.69	.05	15.44	<.001*	**.69**	**.05**	**[.60;.78]**
Modality	-.74	.07	-10.27	<.001*	**-.74**	**.08**	**[-.88;-.59]**
Session	.06	.07	.77	.449	**.05**	**.08**	**[-.09 ;.20]**
L2-Proficiency (DL)	.08	.03	2.53	<.05*	**.08**	**.04**	**[.01 ;.15]**
Group	.53	.09	5.88	<.001*	**.53**	**.10**	**[.35 ;.73]**
Modality x Session	.46	.18	2.56	<.05*	**.46**	**.19**	**[.08 ;.81]**
Modality x L2Proficiency	-.06	.05	-1.11	.278	**-.06**	**.06**	**[-.17 ;.05]**
Session x L2Proficiency	-.04	.05	-.67	.510	**-.04**	**.06**	**[-.14 ;.08]**
Modality x Group	-.36	.15	-2.49	<.05*	**-.36**	**.15**	**[-.66 ;-.05]**
Modality x Session x L2Proficiency	.36	13	2.66	<.05*	**.36**	**.14**	**[.10 ;.63]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(dprime ~ Modality + Session + Dialang_Level + Group + Modality:Session + Modality:Dialang_Level + Session:Dialang_Level + Modality:Group + Modality:Session:Dialang_Level + (1 | Participant), data = Data_dprime_Exp1d_NCT_Frcoll_dysctrl, REML = TRUE)

[59] Maximum BF = 2.715 * 10^13, corresponding to the same model formula than those of the final model of LMM (bayes_R^2 = .79, SE = .04, 95% CrI = [0.71, 0.86]).

4.3.4.1.2.Accuracy scores (percentage of correct responses for word trials).

Mean accuracy scores of our participants, on word trials only, according to Modality, Session and Group are presented in Figure 41 below.

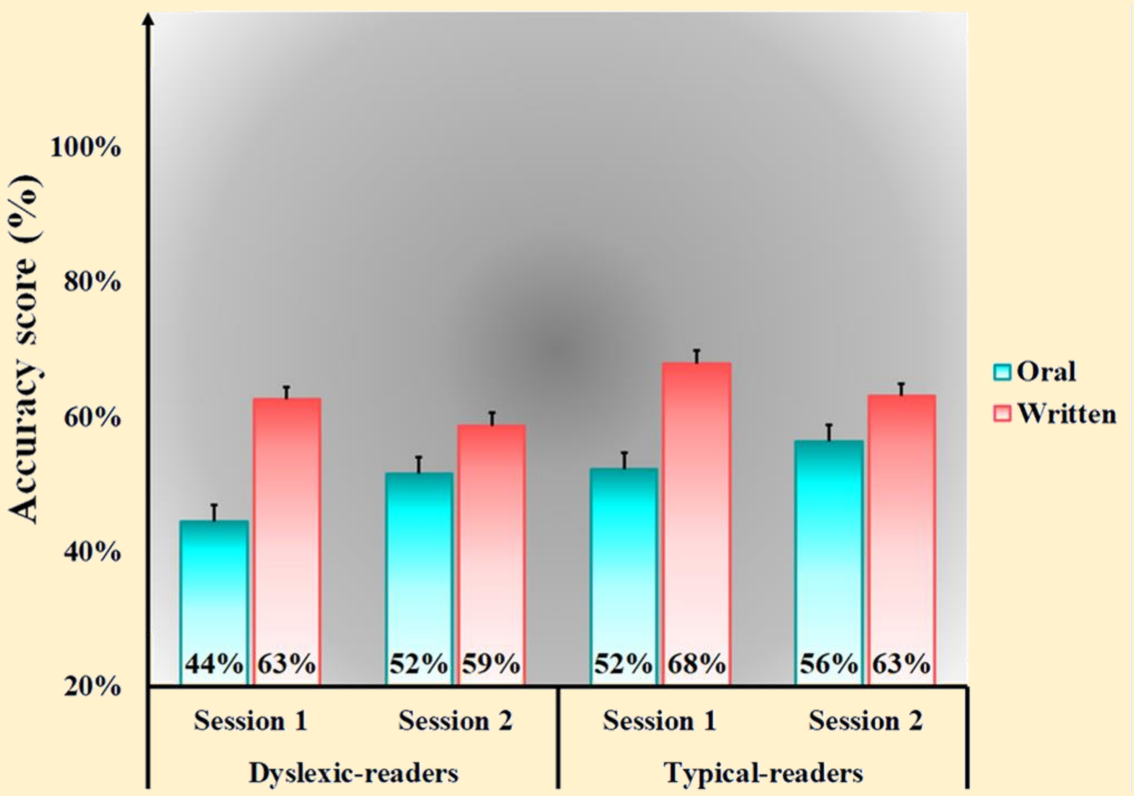

Figure 41. Raw data of Accuracy scores - Non-cognate task - French middle-school students, dyslexic and typical-readers - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each word included by-participant and by-item random intercepts and random slopes considering the Modality, and L2-Proficiency (DL out of 1,000) and Modality (written vs. oral) as fixed effects (best model according to the AIC: $\chi^2 = 50.564$, $p < .001$). Note that Group couldn't be included into the final model. Those fixed and random effects explain 23% of the variance (adjusted $R^2 = .229$).

Accuracy scores were significantly lower in oral modality (51%, SD = 50) than in written modality (63%, SD = 48).

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[60], are reported in Table 22 below.

Table 22. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - Non-cognate task - French middle-school students, typical and dyslexic-readers - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	.41	.21	1.93	.054	**.57**	**.04**	**[.49;.65]**
L2-Proficiency (DL)	.14	.11	1.26	.209	**.02**	**.02**	**[-.01;.07]**
Modality	-.73	.18	-4.15	<.001*	**-.12**	**.03**	**[-.18;-.06]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(Response ~ Dialang_Level + Modality + (1 + Modality | Participant) + (1 + Modality | Item), data = Data_response_words_Exp1dNCT_Frcoll_dysctrl, family = binomial)

4.3.4.2.Cognate task.

4.3.4.2.1.Discrimination rate (d'), cognate and non-cognate items.

Raw data are presented in Figure 42 page 134.

[60] Maximum BF = 314,266,428, corresponding to the same model formula than those of the final model of GLMM.

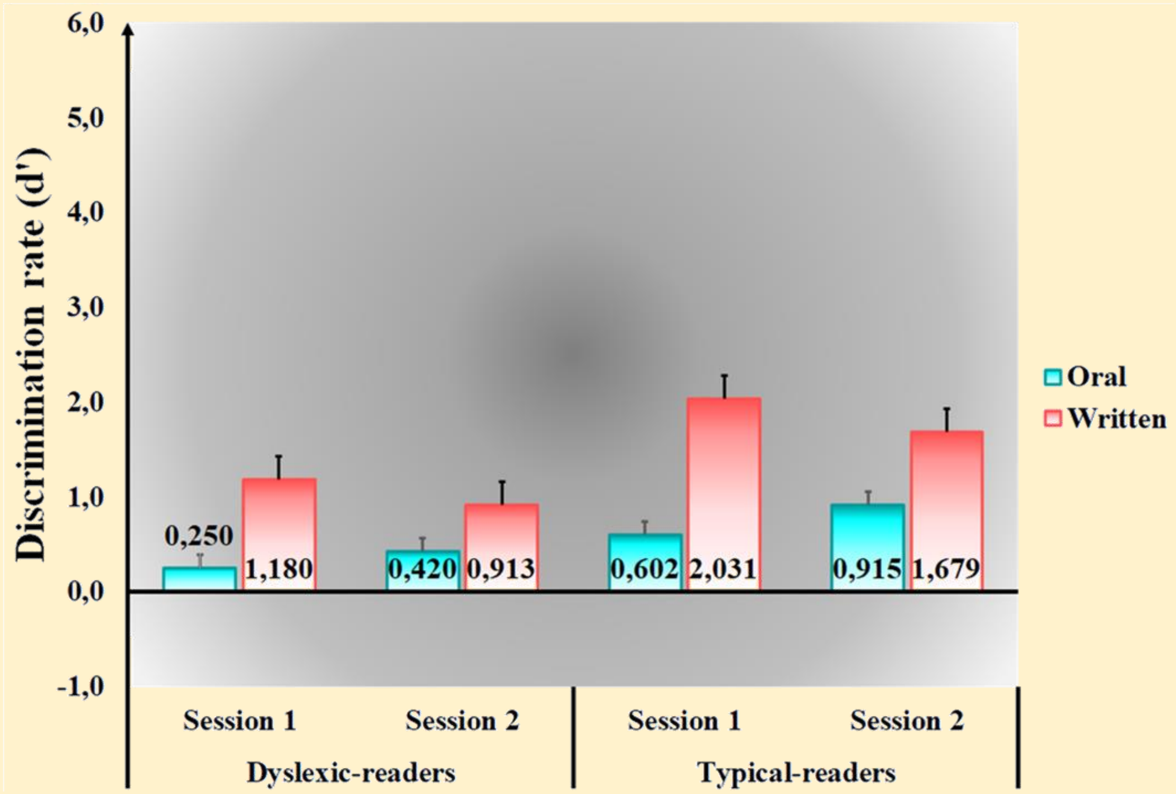

Figure 42. Raw data of d' - Cognate task - French middle-school students, dyslexic and typical-readers - Experiment 1.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts, and Modality (written vs. oral), centred L2-Proficiency (DL out of 1,000) and Group (Dyslexic vs. Typical-readers) as fixed effects (best model according to the AIC: $F(1,101) = 56.369$, $p < .001$). No interaction between those factors could be included into the final model. Those fixed effects explained 37% of the variance (marginal $R^2 = .372$).

Discrimination rates (d') were significantly lower in oral modality (.540, SD = .54) than in written one (1.442, SD = 1.04), and for dyslexic-readers (.685, SD = .863) than for typical-readers (1.297, SD = .92). In addition, L2-Proficiency effect was significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .14 of the d' of the participant, as displayed by Figure 43 page 135.

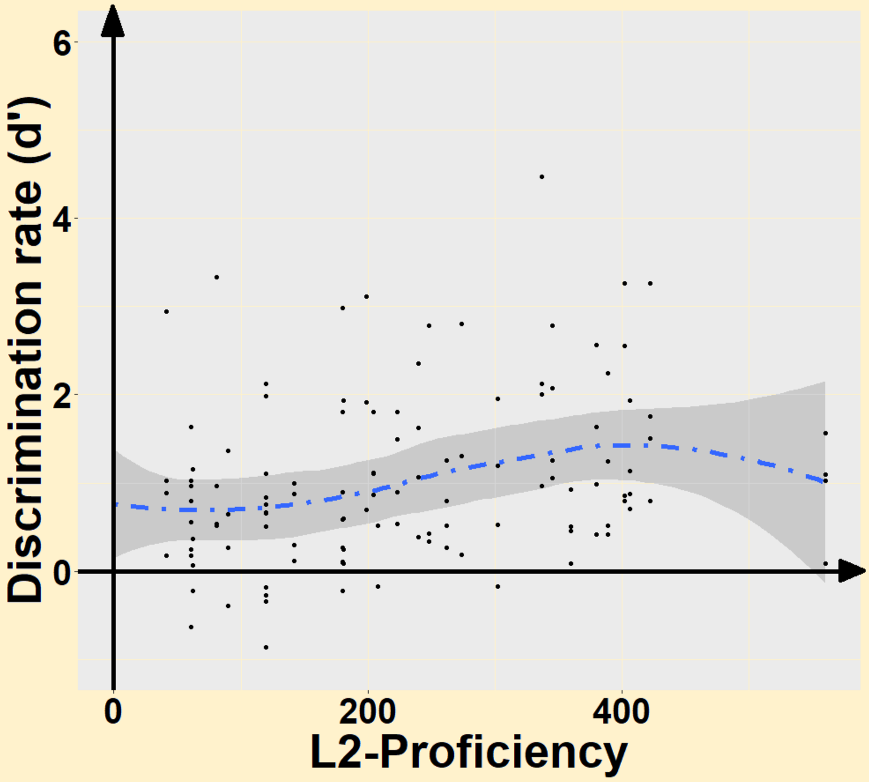

Figure 43. Discrimination rate as a function of Dialang score (out of 1,000): dotdashed line is the regression line, the area around is the 99% confidence interval - Cognate task - French middle-school students, dyslexic and typical-readers - Experiment 1

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[61], are reported in Table 23 below.

Table 23. Parameter estimates of the final model fitted to the d' (**and output from the Bayesian analysis in bold**) - Cognate task - French middle-school students, dyslexic and typical-readers - Experiment 1.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	.99	.08	12.96	<.001*	**.99**	**.08**	**[.84;1.15]**
Modality	-.90	.12	-7.51	<.001*	**-.90**	**.12**	**[-1.15;-.66]**
L2-Proficiency (DL)	.14	.06	2.50	<.05*	**.14**	**.06**	**[.03;.25]**
Group	.54	.16	3.46	<.01*	**.54**	**.16**	**[.23;.85]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(dprime ~ Modality + Dialang_Level + Group + (1 | Participant), data = Data_dprime_Exp1dCT_Frcoll_dysctrl, REML = TRUE)

[61] Maximum BF = 56,855,463,786, corresponding to the same model formula than those of the final model of LMM (bayes_R² = .45, SE = .06, 95% CrI = [.33, .56]).

4.3.4.2.2. Accuracy scores (percentage of correct responses for word trials), cognate and non-cognate items.

Mean accuracy scores of our participants, on word trials only, according to Modality, Session, Cognateness and Group are presented in Figure 44 below.

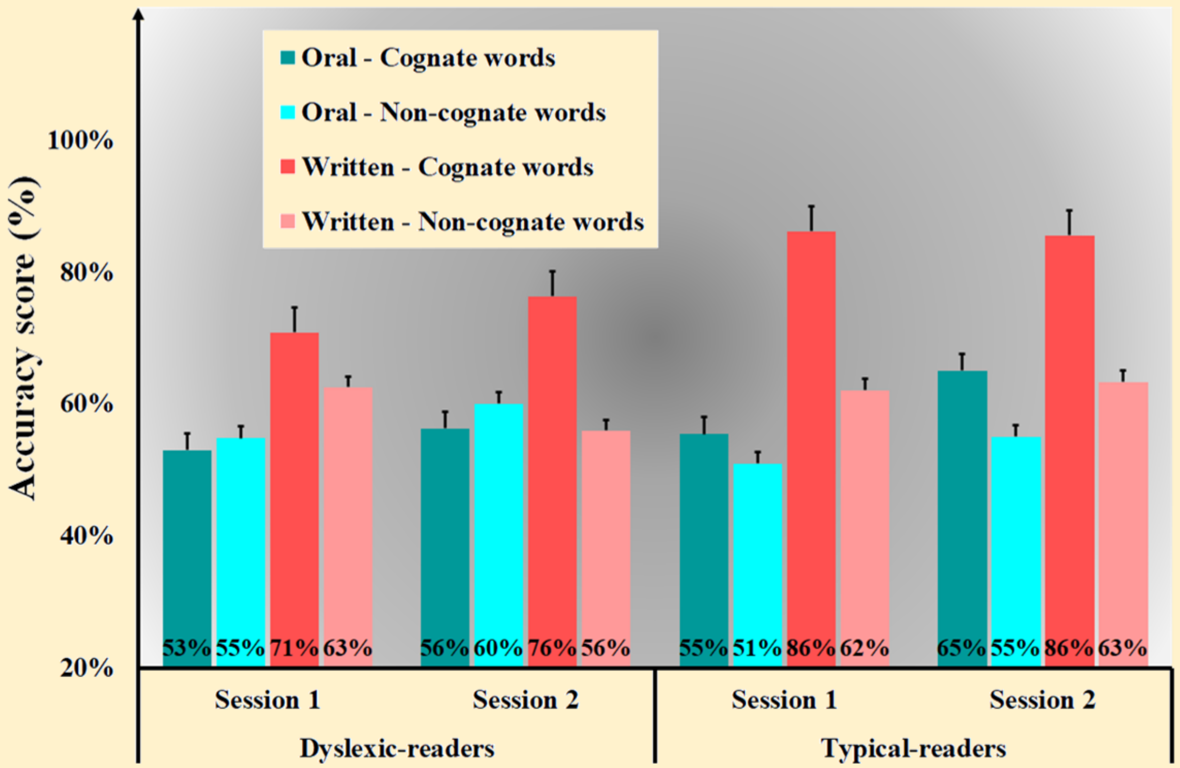

Figure 44. Raw data of Accuracy scores - Cognate task - French middle-school students, dyslexic and typical-readers - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each word included by-participant random intercepts and by-item random intercepts and random slope considering the Modality, and Group (Dyslexic vs. Typical-readers), Modality (written vs. oral), Session (1st vs. 2nd), Cognateness (Cognate vs. Non-cognate words), and the two-way interactions between Group and Modality, Group and Cognateness, and Modality and Cognateness as fixed effects (best model according to the AIC: χ^2 = 18.46, $p < .001$). Those fixed and random effects explain 20% of the variance (adjusted R^2 = .199).

Accuracy scores were significantly lower in oral modality (56%, SD = 50) than in written one (70%, SD = 46), and for non-cognate words (58%, SD = 49) than for cognate words

(69%, SD = 47). Moreover, two-way interactions were significant: a) between Group and Modality, dyslexic-readers being less accurate than typical-readers in written modality but not in oral modality; b) between Group and Cognateness, cognate effect being of higher amplitude for typical-readers than dyslexic-readers; and c) between Modality and Cognateness, cognate effect existing in written modality but not in oral one.

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[62], are reported in Table 24 below. Note that Group effect was non-significant in the model including the interactions, while raw data suggest an effect. We thus performed post-hoc analysis to compare the mean accuracy scores of our independent groups. They showed that there was a group effect with higher accuracy scores for typical-readers (65%, SD = 48) than dyslexic-readers (61%, SD = 49, t(4072.9 = -2.792, p < .01).

Table 24. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - Cognate task - French middle-school students, typical and dyslexic-readers - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	.71	.15	4.79	<.001*	**.72**	**.16**	**[.41;1.03]**
Group	.28	.24	1.15	.253	**.27**	**.26**	**[-.25;.79]**
Modality	-.81	.11	-7.46	<.001*	**-.81**	**.11**	**[-1.04;-.59]**
Session	.14	.07	1.88	.068	**.14**	**.07**	**[-.00;.28]**
Cognateness	-.59	.19	-3.17	<.01*	**-.58**	**.19**	**[-.97;-.20]**
Group x Modality	-.50	.15	-3.38	<.001*	**-.49**	**.15**	**[-.77;-.21]**
Group x Cognateness	-.56	.15	-3.82	<.001*	**-.56**	**.15**	**[-.84;-.28]**
Modality x Cognateness	.99	.21	4.63	<.001*	**.99**	**.23**	**[.56;1.43]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(Response ~ Group + Modality + Session + Cognateness + Group:Modality + Group:Cognateness + Modality:Cognateness + (1 | Participant) + (1 + Modality | Item), data = Data_response_words_Exp1dCT_Frcoll_dysctrl, family = binomial)

[62] Maximum BF = 2.452 * 10^33, corresponding to the same model formula than those of the final model of GLMM.

4.3.4.2.3.Accuracy scores (percentage of correct responses for word trials), cognate items only.

As previously, we performed the same analyses (for accuracy) but including only cognate words. Mean accuracy scores of our participants, on cognate word trials only, according to Modality, Session, Cognate-type and Group are presented in Figure 45 below.

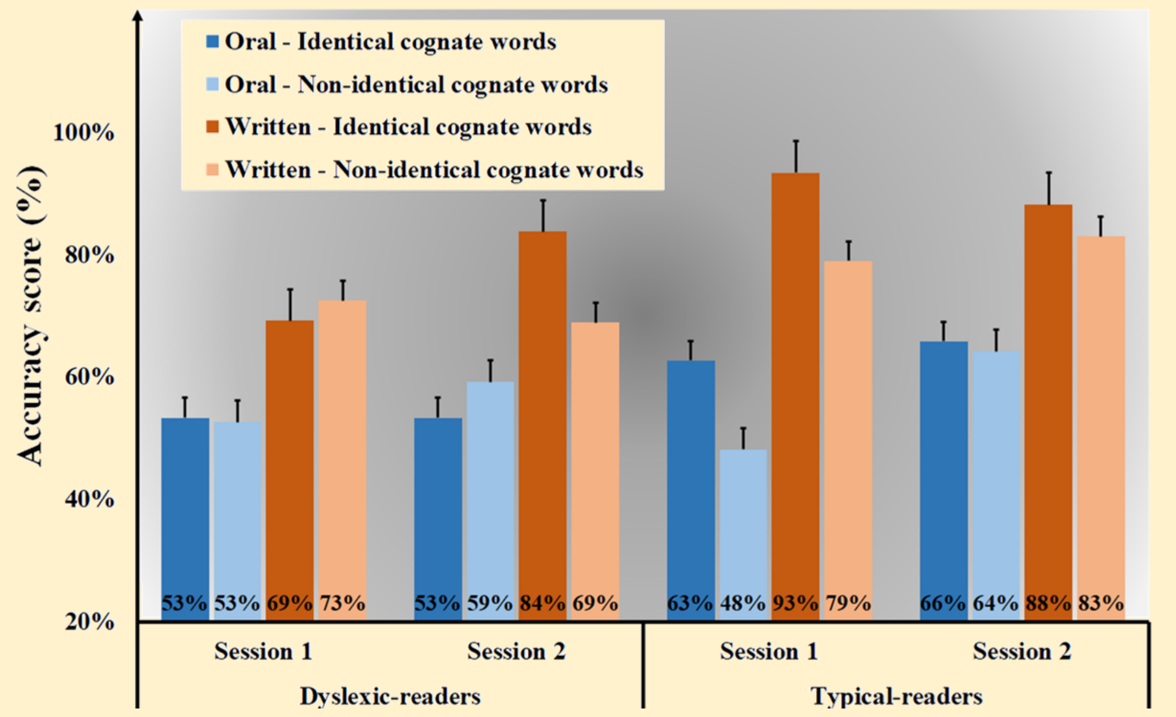

Figure 45. Raw data of Accuracy scores - Cognate task, cognate items only - French middle-school students, dyslexic and typical-readers - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each cognate word included by-participant intercepts and by-item random intercepts and random slope considering the Modality, and Cognate-type (identical vs. non-identical), Group (Dyslexic vs. Typical-readers) and Modality (written vs. oral) as fixed effects (best model according to the AIC: $\chi^2 = 144.52$, $p < .001$). Those fixed and random effects explain 18% of the variance (adjusted $R^2 = .179$).

Accuracy scores were significantly lower in oral modality (57%, SD = 50) than in written one (80%, SD = 40), and for dyslexic-readers (64%, SD = 48) than for typical-readers (73%, SD = 45).

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[63], are reported in Table 25 below.

Table 25. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - Cognate task, cognate items only - French middle-school students, typical and dyslexic-readers - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	.97	.16	6.26	<.001*	**.98**	**17**	**[.65;1.32]**
Cognate-type	.31	.22	1.40	.162	**.32**	**.24**	**[-.16;.80]**
Group	.48	.24	1.96	<.05*	**.49**	**.26**	**[-.01;1.00]**
Modality	-1.24	.15	-8.49	<.001*	**-1.26**	**.16**	**[-1.57;-.95]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(Response ~ Cognate_type + Group + Modality + (1 | Participant) + (1 + Modality | Item), data = Data_response_cognate_words_Exp1dCT_Frcoll_dysctrl, family = binomial)

4.3.4.2.4.Summary of the results.

Table 26 below presents a summary of the results of Experiment 1 among French middle-school students, typical and dyslexic-readers. The aim being to compare typical and dyslexic-readers, main results concerned group effect and its interaction with other factors.

Table 26. Summary of the results of Experiment 1 - French middle-school students, dyslexic and typical-readers.

(M = Modality, S = Session, P = L2 Proficiency, C = Cognateness, CT = Cognate-type, G = Group, ✓ = significant effect, ✗ = non-significant effect)

Task / Analysis	Dependent Variable	M	G	P	S	C/CT	G:C/CT	M:S	P:M:S	M:G	M:C/CT
Non-cognate task	d’	✓	✓	✓	✗	NA	✗	✓	✓	✓	NA
	Accuracy	✓	✗	✗	✗	NA	✗	✗	✗	✗	NA
Cognate task / all stimuli	d’	✓	✓	✓	✗	NA	✗	✗	✗	✗	NA
	Accuracy	✓	✓	✗	✗	✓	✓	✗	✗	✓	✓
Cognate task / cognate stimuli	Accuracy	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗

63 Maximum BF = 4.211 * 10^28, corresponding to the same model formula than those of the final model of GLMM.

4.3.5. English typical-reader university students.

4.3.5.1. Cognate task[64].

We excluded ten participants[65] from the analyses, due to his/her high pseudoword error rate. Finally, we included a remaining Oral-Written-TypEnUniv group of 15 participants and a remaining Written-Oral-TypEnUniv group of 14 participants.

4.3.5.1.1. Discrimination rate (d').

Raw data are presented in Figure 46 below.

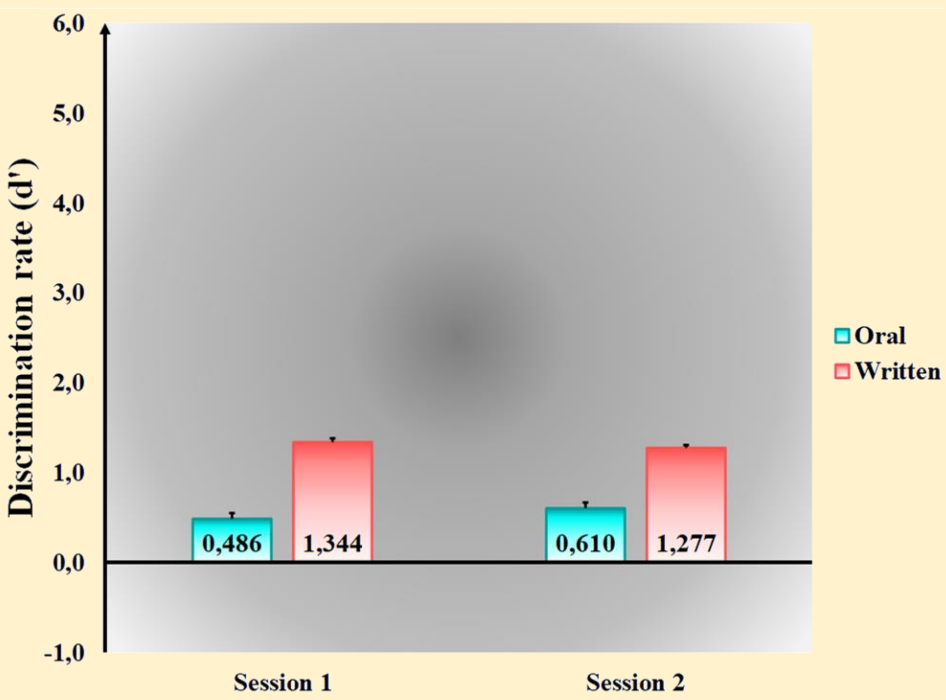

Figure 46. Raw data of d' - English typical-reader university students - Experiment 1.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts, and Modality (written vs. oral) and centred L2-Proficiency (DL out of 1,000) as fixed effects (best model according to the AIC: $F(1,113) = 37.121$ $p < .001$). Those fixed effects explained 24% of the variance (marginal R^2 = .238).

---

[64] Ad a reminder, we proposed to English university students a cognate task in French only, given the difficulty to select items for both a cognate and a non-cognate tasks.

[65] We performed also the analysis, without the exclusion of those participants. The results were similar to those described in this section.

Discrimination rates (d') were significantly lower in oral modality (.55, SD = .49) than in written one (1.31, SD = 1.05). In addition, L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .15 of the d' of the participant, as displayed by Figure 47 below.

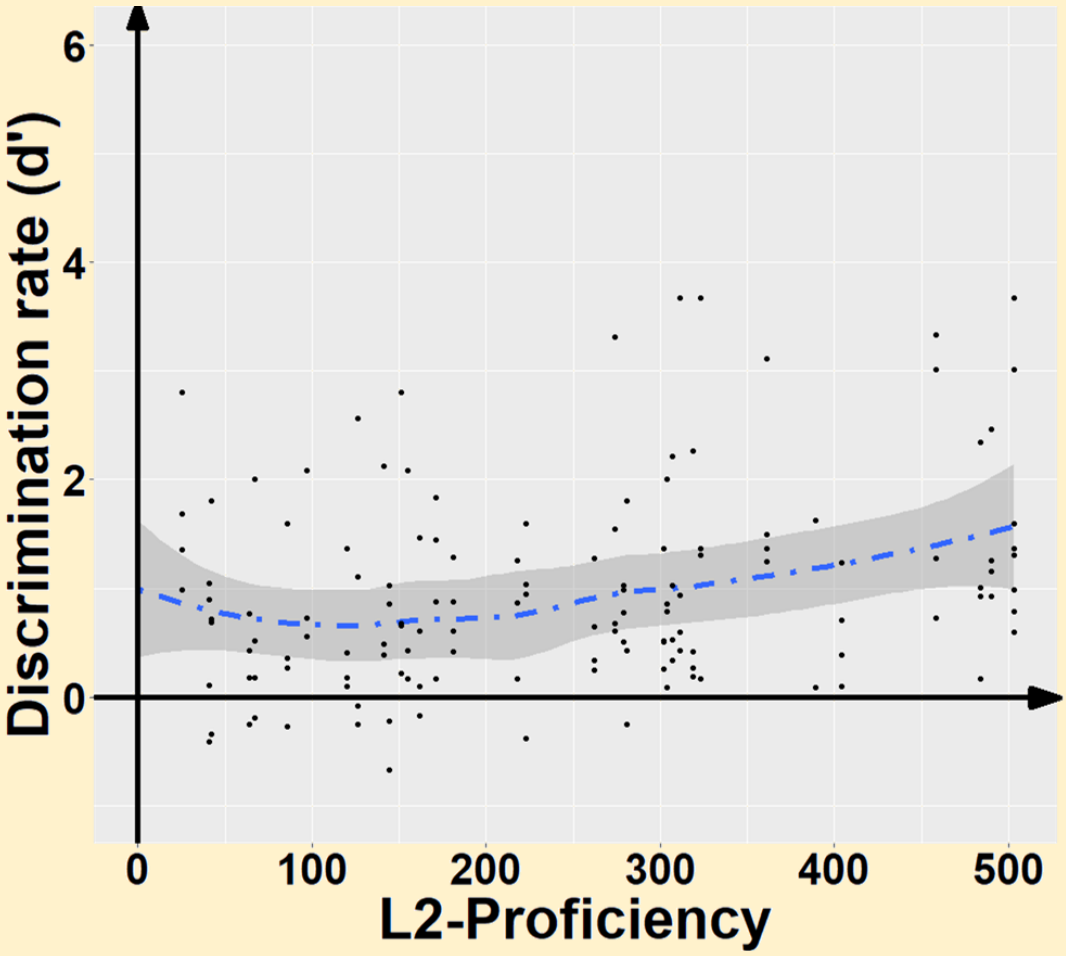

Figure 47. Discrimination rate as a function of Dialang score (out of 1,000): dotdashed line is the regression line, the area around is the 99% confidence interval - English typical-reader university students - Experiment 1

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[66], are reported in Table 27 page 142.

[66] Maximum BF = 8,003,284, corresponding to the same model formula than those of the final model of LMM (bayes_R^2 = .29, SE = .06, 95% CrI = [.17, .41]).

Table 27. Parameter estimates of the final model fitted to the d' (**and output from the Bayesian analysis in bold**) - English typical-reader university students - Experiment 1.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	1.32	.09	13.96	<.001*	**1.32**	**.10**	**[1.12;1.50]**
Modality	-.76	.13	-6.09	<.001*	**-.76**	**.13**	**[-1.01;-.51]**
L2-Proficiency (DL)	.15	.05	3.22	<.01*	**.15**	**.05**	**[.06;.25]**

Note: Significant effects at a p < .05 level are marked with a ⁎. Final model formula: lmer(dprime ~ Modality + Dialang_Level + (1 | Participant), data = Data_dprime_Exp1eCT_Enguniv_ctrl, REML = TRUE)

4.3.5.1.2.Accuracy scores (percentage of correct responses for word trials), cognate and non-cognate items.

Mean accuracy scores of our participants, on word trials only, according to Modality and Session are presented in Figure 48 below.

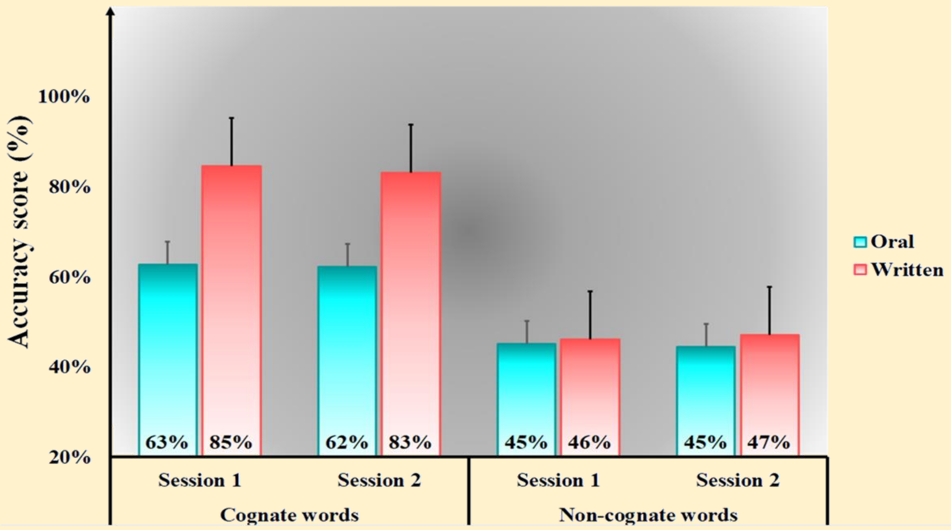

Figure 48. Raw data of Accuracy scores - English typical-reader university students - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each word included by-participant random intercepts and random slopes considering Modality and Cognateness, and by-item random intercepts and random slope considering the Modality, and Modality (written vs. oral), L2Proficiency (DL score out of 1,000), Cognateness (Cognate vs. Non-cognate words), and the two-way interaction between Modality and Cognateness as fixed effects (best model according to the AIC: $\chi^2 = 19.23$, $p < .001$). Those fixed and random effects explain 36% of the variance (adjusted $R^2 = .359$).

Accuracy scores were significantly lower in oral modality (54%, SD = 50) than in written one (65%, SD = 48), and for non-cognate words (46%, SD = 50) than for cognate words (73%, SD = 44). Moreover, the two-way interaction between Modality and Cognateness was significant, a modality effect (*i.e.*, a difference in accuracy scores between modalities) existing for cognate words only. In addition, L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in an increase of .23 of the d' of the participant, as displayed by Figure 49 below[67].

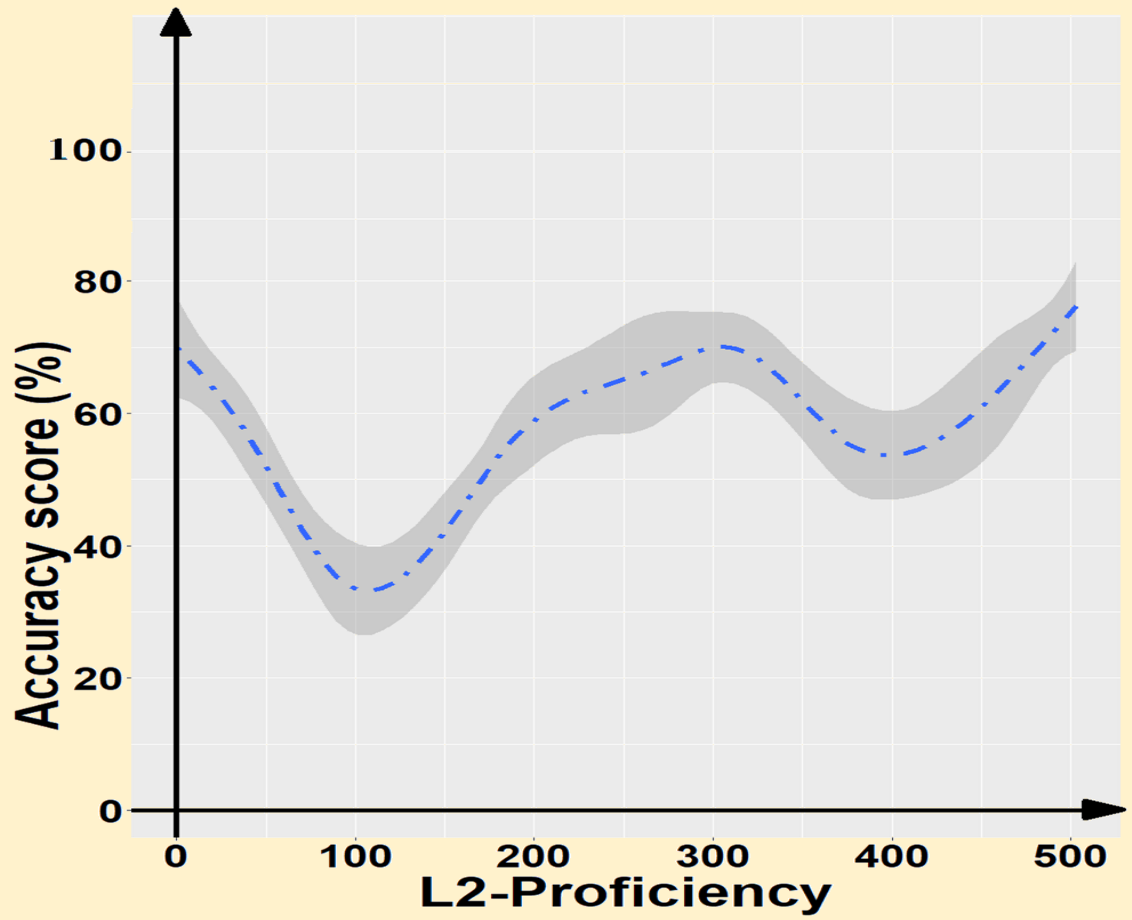

Figure 49. Accuracy score as a function of Dialang score (out of 1,000): dotdashed line is the regression line, the area around is the 99% confidence interval - English typical-reader university students - Experiment 1.

[67] Note on Figure 49 that the regression line seemed somehow odd, probably in relation to some noise, having more impact on word recognition among extreme proficiency (lowest and highest) participants.

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[68], are reported in Table 28 below.

Table 28. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - English typical-reader university students - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	2.10	.27	7.91	<.001*	**1.83**	**.18**	**[1.48;2.19]**
Modality	-1.46	.22	-6.56	<.001*	**-1.24**	**.18**	**[-1.59;-.89]**
L2 Proficiency	.26	.10	2.47	<.05*	**.20**	**.03**	**[.15;.25]**
Cognateness	-2.37	.30	-7.98	<.001*	**-2.03**	**.24**	**[-2.52;-1.57]**
Modality x Cognateness	1.36	.28	4.80	<.001*	**1.17**	**.25**	**[.68;1.65]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(Response ~ Modality + Dialang_Level + Cognateness + Modality:Cognateness + (1 + Modality + Cognateness | Participant) + (1 + Modality | Item), data = Data_response_words_Exp1eCT_Engluniv_ctrl, family = binomial)

We will now present additional analysis concerning cognate items only.

4.3.5.1.3.Accuracy scores (percentage of correct responses for word trials), cognate items only.

As previously, we performed the same analyses (for accuracy) but including only cognate words[69]. Mean accuracy scores of our participants, on cognate word trials only, according to Modality, Session and Cognate-type are presented in Figure 50 page 145.

[68] Maximum BF = 1.024 * 10^87, corresponding to the same model formula than those of the final model of GLMM.

[69] Likewise, we performed also additional analysis, similar to that of the non-cognate task, in order to replicate our results and to determine the impact of cognate words included into the lists of stimuli on L2 non-cognate word recognition. The results were similar to those of the non-cognate task.

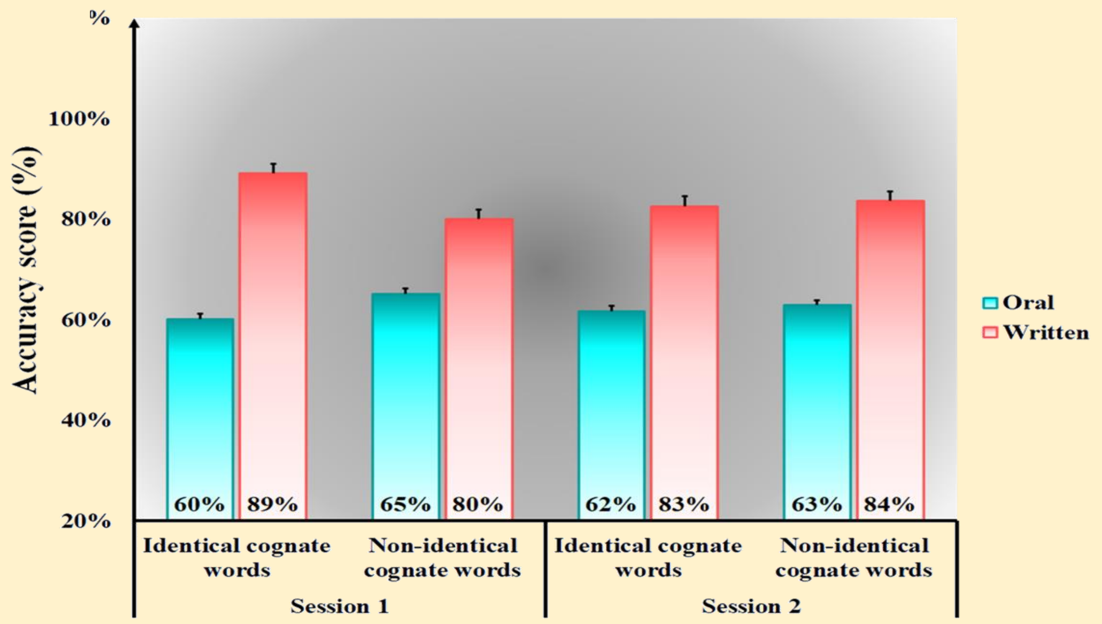

Figure 50. Raw data of Accuracy scores on cognate word trials only - English typical-reader university students - Experiment 1.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each cognate word included by-participant intercepts and by-item random intercepts, and Modality (written vs. oral) and L2Proficiency (Dialang score out of 1,000) as fixed effects (best model according to the AIC: $\chi^2 = 5.68$, $p < .05$). Those fixed and random effects explain 26% of the variance (adjusted $R^2 = .258$).

Accuracy scores were significantly lower in oral modality (63%, SD = 45) than in written one (84%, SD = 37). In addition, L2-Proficiency effect was also significant, an increase of Dialang score of 100 out of 1,000 resulting in an increase of the mean accuracy of the participant of .25.

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[70], are reported in Table 29 page 146.

[70] Maximum BF = 7.308 * 10^27, corresponding to the same model formula than those of the final model of GLMM.

Table 29. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) on cognate words - Cognate task - English typical-reader university students - Experiment 1.

Predictors	b	SE b	z	p	**b**	**SE b**	**95% CrI**
(Intercept)	2.06	.24	8.58	<.001*	**2.09**	**.26**	**[1.59;2.61]**
Modality	-1.45	.14	-10.76	<.001*	**-1.46**	**.14**	**[-1.72;-1.19]**
L2Proficiency	.25	.10	2.52	<.05*	**.25**	**.11**	**[.04;.47]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(Response ~ Modality + Dialang_Level + (1 | Participant) + (1 | Item), data = Data_response_cognate_words_Exp1eCT_Engluniv_ctrl, family = binomial)

4.3.5.1.4. Summary of the results.

Table 30 below presents a summary of the main results of the cognate task among English typical-reader university students.

Table 30. Summary of the results of Experiment 1 – English typical-reader university students.

(M = Modality, S = Session, P = L2 Proficiency, C = Cognateness, CT = Cognate-type, ✓ = significant effect, ✗ = non-significant effect)

Task / Analysis	Dependent Variable	M	S	P	C / CT	C/CT:M
Cognate task / all stimuli	d'	✓	✗	✓	NA	NA
	Accuracy	✓	✗	✓	✓	✓
Cognate task / cognate stimuli	Accuracy	✓	✗	✓	✗	✗

4.4. Discussion.

Experiment 1 aimed to determine the degree to which the first stage of word processing, namely word recognition, is sensitive to modality among intermediate proficiency bilinguals, in terms of accuracy. In order to analyse the links between the expected modality effect and L2 proficiency, L1 reading efficiency and language features on the one hand, and to adopt a cross-sectional perspective to determine whether it depends on skills development on the other hand, Experiment 1 was proposed to five groups of participants. We will propose in this section a brief summary of the results of each group and their simple interpretation: see Table 31 below. This table contains the main results concerning Accuracy scores[71] for each task, without distinction between both analyses of the Cognate task. Moreover, the direction of effects is not indicated here, but will be discuss in the following interpretation. A theoretical discussion concerning all experiments will be proposed at the end of this manuscript.

Table 31. Summary of the results on Accuracy scores - Experiment 1 - all groups.

(Fr = French, En = English, U = University students, M = Middle-schoolers, Typ = Typical-readers, Dys = Dyslexic-readers, NC = Non-cognate, M = Modality, G = Group, S = Session, P = L2 Proficiency, C = Cognateness, CT = Cognate-type, ✓ = significant effect, ✗ = non-significant effect)

Group	Task	M	S	P	G	C / CT	M:S	M:P	M:G	C/CT:M	G:S	P:M:S	G:M:S
TypFrUniv	NC	✓	✗	✓	NA	NA	✗	✗	NA	NA	NA	✗	NA
	C	✓	✗	✓	NA	✓	✗	✓	NA	✓	NA	✗	NA
DysFrUniv	NC	✓	✗	✓	✗	NA	✗	✓	✗	NA	✓	✓	✗
	C	✓	✗	✓	✓	✓	✗	✓	✓	✓	✗	✗	✓
TypFrMid	NC	✓	✗	✓	NA	NA	✗	✗	NA	NA	NA	✗	NA
	C	✓	✓	✓	NA	✓	✗	✗	NA	✓	NA	✗	NA
DysFrMid	NC	✓	✗	✗	✗	NA	✗	✗	✗	NA	✗	✗	✗
	C	✓	✗	✗	✓	✓	✗	✗	✓	✓	✗	✗	✗
TypEnUniv	C	✓	✗	✓	NA	✓	✗	✗	NA	✓	NA	✗	NA

4.4.1. First hypothesis: modality effect on L2 word recognition, in favour of the written modality.

Experiment 1 highlighted the expected **modality effect on L2 word recognition**, with written words more accurately recognized than spoken ones, among French typical-reader

[71] We decided to present here only the effects on Accuracy scores, for more efficacy and conciseness.

university students. This is congruent with the results of Veivo and collaborators, who found a modality effect in favour of the written one on L3 translation accuracy among Finnish students (Veivo, 2017; Veivo et al., 2015). This effect is probably linked with different activation mechanisms depending on the modality: lexical in written modality – the whole orthographic lexical information being available simultaneously – and sub-lexical in oral one – because of the temporality of the phonological input. In addition to the conclusion of Veivo's studies, this result demonstrates that the access to L2 orthographic lexical representations is easier than that to L2 phonological lexical representations, among intermediate proficiency bilinguals.

Concerning middle-school students, the main findings concerned differences and similarities between university and middle-school students, regarding their pattern of results. Indeed, we couldn't directly compare both groups, because middle-schoolers were beginner learners of English as an L2. Thus, they had lower L2 proficiency than university students, and they knew fewer English words. This narrow vocabulary breadth explains our need to adapt the stimuli lists, precluding any direct comparison. Interestingly, we observed approximately the same pattern of results. In particular, French typical-reader middle-school students presented also a modality effect, **in favour of the written one**.

Surprisingly, **dyslexic-readers** (middle-schoolers like university students) showed a **modality effect in favour of the written modality**, as typical-readers did. This is particularly interesting, and somewhat incongruent with previous findings, which demonstrated that dyslexic-readers' difficulties in L1 are at least partially transferred, and thus also observed, in L2 (Lindgrén & Laine, 2011a; Palladino et al., 2013; van Setten et al., 2017). This surprising but major finding could be linked with: a) their difficulties to learn the specific OPM of the L2, given their phonological deficit (Lindgrén & Laine, 2011a; Snowling, 1981); b) the practicalities of L2 learning in an academic context, which is responsible for a bias in exposure in favour of the written modality; or also c) language features (such as within-language orthographic inconsistency or between-language incongruence, see for the impact of orthographic depth on dyslexic-readers skills: Lindgrén & Laine, 2011b). Those three hypotheses may be complementary. Therefore, language features had an impact on the amplitude of this modality effect, and must have had also an impact on the results of dyslexic-readers, as demonstrated in L1 by Lindgrén and Laine (2011b).

4.4.2. Second hypothesis: interaction between modality and proficiency effects.

Concerning French typical-reader university students, their modality effect interacted with L2 Proficiency. This is congruent with the results of Veivo et al. (2015) who described a modality effect on L3 translation accuracy, in favour of the written modality, and an interaction between L3 proficiency and modality. Note that Experiment 1 demonstrated the **interaction between L2 proficiency and modality only in the cognate task** on L2 word recognition accuracy – in the main analysis considering all items as well as in the further one considering cognate items only. The modality effect – *i.e.*, the difference in accuracy between modalities – was more important for participants from lower L2 proficiency than for those from higher L2 proficiency. The non-cognate task did not reveal this type of interaction, indicating that **cognate items modified the links between modality and proficiency effects** and was responsible, at least partially, for this difference between participants from various L2 proficiencies. This could be in relation to their between-language similarities, that was higher orthographically than phonologically, the lowest proficiency participants using these cues to help their written word recognition, while they did not consider them as cues in oral modality, increasing the amplitude of the modality effect.

This interpretation was also congruent with the results of other groups, notably those of dyslexic-readers or middle-schoolers, but also those of English-French bilinguals, having lower

L2 proficiency (see their respective background test results) and less interaction between modality and L2 proficiency. Critically, it should be noted that the modality effect (*i.e.*, the difference in accuracy between modalities) seems to be **more important for middle-school** students (10 points) **than for university students** (five points). This difference could be related to the lower L2 proficiency of middle-schoolers, manifested mainly by lower accuracy scores in oral modality, increasing the difference between modalities, even if a direct comparison was not possible. This is congruent with the study of Veivo, who demonstrated a modality effect interacting with L2 proficiency (Veivo et al., 2015). Likewise, this is consistent with the findings among **English-French bilinguals**, who presented a **modality effect, in favour of the written one, seeming to be more important** (11 points) **than that of French-English bilinguals** (five points), while their L2 proficiency seemed lower (see their respective background test results).

4.4.3. Third hypothesis: interaction between modality and cognate effects.

To our knowledge, Experiment 1 was the first to directly compare L2 cognate word recognition across modalities. It demonstrated that the well-known **cognate facilitation effect** should be put into perspective (see for a theoretical discussion about this interaction between modality and cognate effect the "General discussion" section page 246). Indeed, the cognate task revealed it **in terms of accuracy** in all of our five groups of participants. However, the **interaction between Modality and Cognateness** was significant among French-English middle-schoolers and English-French bilinguals only, cognate effect (*i.e.*, the difference in accuracy scores between cognate and non-cognate words) being of higher amplitude in written modality than in oral one. This interaction was not highlighted among French-English university students, suggesting that it depends on L2 proficiency. Indeed, as mentioned previously, French middle-schoolers were less proficient in English than French university students, and English-French university students were less proficient in French than French-English university students were in English (see their respective background test results)[72]. Therefore, everything happened as if **cognate words hamper spoken word recognition**, only for the lowest proficiency participants. This could be interpretated as a consequence of L1 influence on L2 word recognition. Actually, the lowest proficiency bilinguals would probably be less confident in their ability to recognize L2 words. They would therefore base more their decision on L1 cues than higher proficiency bilinguals would do. Cognate words sharing semantics and orthographic forms more than phonological forms, they would not be considered as strong cues by lower proficiency bilinguals in the oral modality. Conversely, cognate words would be recognized easier in written modality because they "look like" French words. Therefore, cognate words would facilitate written word recognition and hamper spoken one among lower proficiency participants bilinguals. Considering higher proficiency bilinguals, they are assumed to be more confident in their ability to recognize L2 words, compared to lower proficiency bilinguals. They would thus be less hampered in oral modality by the lack of phonological sharing between translation equivalents. Therefore, this could explain the absence of interaction between Cognateness and Modality among the highest proficiency bilinguals (*i.e.,* French-English university students – intermediate proficiency bilinguals, compared to middle-schoolers or English-French university students – low proficiency bilinguals). With the increase of L2 proficiency, late bilinguals are able to recognize cognate spoken words as accurately as cognate written words, and thus to benefit from the orthographic without phonological sharing between those translation equivalents in both modalities. This suggests the creation of strong phonological representations of cognate words, as L2 proficiency

[72] Even if it is difficult to directly compare both proficiencies, given that we are not confident in the fact that a score of 200 out of 1,000 in the French Dialang Level test was completely equivalent to the same score in the English version of this test.

increases, through the enhancement of the ability to master the associated OPM and mostly through the increase of their spoken vocabulary knowledge.

More, French university students presented a significant interaction between Modality and Cognate-type, identical cognate words being recognized more accurately than non-identical ones in written modality, but less accurately in oral modality. This indicated that a complete orthographic overlap helps L2 written word recognition, through a combine activation of both L1 and L2 orthographic representation of this word, being identical. This is consistent with the literature on identical and non-identical cognate word recognition (Duyck et al., 2007; Van Assche et al., 2012), showing a stronger facilitation effect for identical cognate words than non-identical ones. Conversely, a complete orthographic overlap without a complete associated phonological overlap hampers L2 spoken word recognition, through a simultaneous activation of two possible phonological representations, that in L2 being less activated than that in L1, due to daily use and exposure to both languages, responsible for diverse baseline activation level (see Blumenfeld & Marian, 2007; Wu et al., 2019).

In addition, cognate effect was present among dyslexic-readers, despite their difficulties in written language processing, although the overlap between those translation equivalents is mainly orthographic, indicating that dyslexic-readers had taken advantage from this between-languages orthographic similarity. This is probably in relation to the fact that the cognate stimuli used for this L2 word recognition experiments are the translation equivalents of L1 words already well-known by dyslexic-reader participants (*e.g.,* “excuse” for identical cognate words or “adult” for non-identical cognate words). This is also congruent with the modality effect they presented on L2 word recognition accuracy.

The fact that we failed to observe an interaction between modality and cognate-type among middle-schoolers, while it was highlighted among university students, indicates that even a complete orthographic overlap did not help them to better recognize L2 words. Those results are congruent with the BIA-d model (Grainger et al., 2010) among those beginner L2 learners, needing to use translation equivalents for L2 word recognition, in relation to their low L2 proficiency. We proposed the following interpretation of the absence of interaction between modality and cognate-type among middle-schoolers: cognate words, and notably identical ones, being recognized as French words, they would have hampered the task, through an activation of the incorrect language node.

Finally, French-English bilinguals presented a cognate effect, with five points higher accuracy scores for cognate words than non-cognate ones, whereas English-French bilinguals showed the same type of cognate effect, with an amplitude of 27 points, with only 46% of non-cognate words being recognized. This seems to indicate that English-French bilinguals used the between-language orthographic similarity more than French-English bilinguals, during L2 word recognition. Note that middle-schoolers had a 15 points amplitude of the cognate effect. This huge difference in the amplitude of this cognate effect between French-English and English-French bilingual university students could be explained by both English language features and participants' L2 proficiency. Indeed, even though it is impossible to say that a score of 200 out of 1,000 in French Dialang Level is equivalent to the same score in English Dialang Level, it seemed that French-English bilinguals had higher L2 proficiency than English-French bilinguals (see Appendix 13 and 18 pages 328 and 334). L2 learners in France and in Scotland would not have achieved the same L2 proficiency, despite the similarities of practicalities of L2 learning in both countries. Notably, spoken word recognition was less efficient among English-French bilinguals. This could be linked with the less exposure to French language through medias in English-speaking countries than that to English language in French-speaking countries. More, English language features, and in particular its orthographic inconsistency, could also explain the L2 spoken word recognition difficulties of English-French bilinguals, training them not to be too attentive to OPM[73], and to preferentially use lexical cues than sub-lexical ones to recognize words.

Therefore, cognate facilitation effect seems thus to clearly exist in the written modality, while the presence of a complete orthographic overlap between translation equivalents would hamper spoken word recognition.

4.4.4. Fourth hypothesis: Group effect (*i.e.*, differences between typical and dyslexic-readers).

In previous sections, we discussed the fact that dyslexic-readers present the same pattern of results than typical-readers. However, even if the pattern was similar, the question remained whether the groups of dyslexic and typical-readers differed from each other.

Interestingly, considering the comparison between dyslexic and typical-readers, we observed a main effect of group on word recognition accuracy when considering cognate words only in the cognate task. We failed to observe this main group effect in the other analysis – for the linear mixed-effect modelling, because we highlighted significant interactions between group and other factors. However, dyslexic-readers presented lower accuracy scores than typical-readers in both cognate and non-cognate tasks. This is consistent with the literature demonstrating that their difficulties in L1 are also observed in L2 (Lindgrén & Laine, 2011a; Palladino et al., 2013). Therefore, they presented lower accuracy scores than typical-readers in written modality. Besides, because their reading difficulties are at least partially in relation to a phonological deficit, and due to the inconsistency of English orthography and the incongruence between English and French orthographies, they also presented lower accuracy scores than typical-readers in oral modality.

[73] OPM = Orthography-to-Phonology Mappings.

4.4.5. Exploratory analysis of the session effect.

As mentioned previously, a session effect would indicate a benefit from one modality over the other, with higher accuracy scores in the second session of word recognition than in the first one.

Experiment 1 demonstrated no session effect in terms of accuracy, during the non-cognate task, among all groups. This is congruent with the results of Veivo et al. (2015) who did not find an effect of the order of the test in their second experiment of L3 translation. This finding suggests that hearing an English non-cognate word activates a phonological lexical representation, which intermediate proficiency bilinguals are not able to use to improve their secondary written word recognition in terms of accuracy. Therefore, when they saw the same word they had just heard, they recognized it as accurately as if they had not heard it before. Likewise, their orthographic lexical representation, activated when they saw a written English word, does not help to improve the accuracy of secondary spoken word recognition. This could be due to the fact that several OPM can be applied for this word. Thus, the phonological product of these mappings is likely to be mismatched with their phonological representations of English words. When they heard the same word just after, they derived no benefit from the first presentation, the correct one not being activated enough, and a lexical competition occurring between the various phonological representations activated.

In the cognate task, no session effect was demonstrated, except for the group of French typical-reader middle-schoolers considering the analysis of cognate words only. This session effect indicates a reciprocal benefit from one modality over the other. Those results could be due to the fact that cognate items activate their lexical representations easier than non-cognate ones, due to their between-language orthographic similarity. This pre-activation helped bilingual individuals to choose the correct mappings to apply for the secondary word recognition. This finding suggests that middle-schoolers being beginner L2 learners – with low L2 proficiency compared to university students (see their respective background results), they have such imprecise phonological representations of L2 words that they are able to adapt those representations to a new encountered word.

Critically, during the non-cognate task of French university students, with typical and dyslexic-readers, the three-way interaction between group, modality and session was significant, a session effect existing for typical-readers only, consisting in a huge difference with the results of typical-readers taken separately, probably due to the pairing of our groups of participants on L2 proficiency. Indeed, we observed in both tasks an interaction between modality and L2 proficiency, which is congruent with the results of Veivo et al. (2015). The pairing of participants on this parameter would thus have had an influence on the results: dyslexic-readers presenting lower L2 proficiency than the group of typical-readers, paired typical-readers were those who presented the lowest proficiency among the latter group.

Finally, English-French bilinguals displayed a complete absence of session effect, indicating that the links between orthographic and phonological lexical representations are less robust in French as an L2 than in English as an L2.

4.4.6.Limitations.

There are some limitations to this study, such as the fact that the experimental design used in Experiment 1 did not allow a complete analysis of the modality effect on latencies which would be interesting to understand L2 word processing mechanisms properly. Indeed, the lack of session effect in terms of accuracy raised the question of the existence of this effect on latencies. Actually, if a session effect exists, indicating a benefit from one modality over the other, it could manifest itself by: a) accuracy differences; b) latency differences; or c) both accuracy and latency differences. However, it is technically impossible to purely analyse accuracy and latencies with the same paradigm, latency analysis needing a ceiling effect, while accuracy analysis necessitates the absence of floor and/or ceiling effect. It is therefore necessary to conduct further experiments to analyse L2 word recognition latencies across sessions.

Furthermore, it should be noted that some figures displayed the existence of a huge variability, notably considering accuracy scores. This high variability is responsible for a kind of noise in the data, which imposed an extreme caution when analysing those results.

4.5. Conclusion.

In conclusion, our results argued in favour of the existence of a relative modal-dependent lexical representations of L2 words, in English among French-English late bilinguals as in French among English-French late bilinguals, and this from the beginning of L2 learning. Indeed, the access to lexical representation in L2 does not seem to be effective without taking modality into account, among (low to) intermediate proficiency bilingual participants. Critically, our results indicate that the well-known cognate facilitation effect needs to be nuanced, because it does not always lead to facilitation. Conversely, it is modal-dependent: facilitating in the written modality but hampering spoken word recognition. Moreover, our results demonstrated that dyslexic-readers, since the beginning of L2 learning, have taken advantage from the bias in exposure in favour of the written modality, despite their difficulties in written language processing, probably because of their sensitization to orthographic inconsistency and phonological features of a language during their speech therapy, demonstrating their ability to transfer those skills and knowledge from the L1 to the L2. Finally, language features (notably English language orthographic inconsistency) seem crucial, having an impact on the various effect amplitudes. In order to control this modality effect in L1, we proposed the same experimental protocol, but in L1, to our five groups of participants, constituting Experiment 2. Indeed, as dyslexic-readers present a modality effect in L2 in favour of the written modality, despite their difficulties in written stimuli processing, it is crucial to determine the extent to which this type of modality effect could also appear in L1. More, in order to analyse latencies, we built another experimental design, assuring a sufficient rate of word recognition allowing an analysis of reaction times satisfying sufficient statistical power, among other participants, constituting Experiments 3 (in L2) and 4 (control in L1).

Chapter 5. Experiment 2: Does modality matter in L1 word recognition accuracy?

5.1. Introduction.

Given the modality effect we highlighted on L2 word recognition accuracy in Experiment 1, especially among the specific population of dyslexic-readers, we wanted to control whether this type of modality effect exists also in L1. Indeed, Experiment 1 highlighted a modality effect on L2 word recognition accuracy, in favour of the written modality, in both English and French languages, among typical and dyslexic-readers. The question then arises as to the existence of a modality effect in L1, especially given the fact that written language is learned much later than oral language in L1. We therefore conducted an experiment in L1, using the same paradigm as in Experiment 1, among the same five groups of participants.

From a theoretical point of view, the dual-route cascaded model of "visual word recognition and reading aloud" in L1 (Coltheart et al., 2001) hypothesized two possible pathways for L1 written word recognition: the phonological and the lexical pathways. The **phonological pathway** is based on GPC[74] rules and allows new word and pseudoword decoding among typical-readers, while the **lexical pathway** is based on a direct access to the orthographic form of familiar words, secondarily activating the associated phonological form of each word.

Dyslexic-readers presenting a phonological deficit, with an alteration in the ability to access phonological representations from written words (Law et al., 2017; Norton et al., 2015; Peterson & Pennington, 2015; Ramus, 2010; Ramus & Szenkovits, 2008; Snowling, 1981;

[74] GPC = Grapheme-Phoneme Correspondences.

Ziegler & Goswami, 2006), it would impair reading *via* the phonological pathway during the learning of reading, and would then compromise the establishment of the lexical pathway (Coltheart et al., 2001; Gangl et al., 2017).

It seems therefore relevant to question the impact of modality on L1 word recognition, notably among dyslexic-readers, themselves presenting a modality effect in favour of the written modality on L2 word recognition. Note that some experiments led us to assume the existence of a modality effect in L1 word recognition, in favour of the written modality, which depends on word difficulty, and thus on lexical frequencies (Connine et al., 1990; López Zunini et al., 2020; Turner et al., 1998; Wolf et al., 2021). Experiment 2 thus addressed the question as to the degree to which word recognition is sensitive to modality in L1, notably among dyslexic-readers, and concerning rare words. We used the same type of paradigm as in Experiment 1, using a repetition of stimuli lists during two lexical decision tasks, one in each modality, performed one after the other, and with a counterbalanced order of presentation of modalities across participants. We expected to highlight, given their written stimuli processing difficulties, the existence of a **modality effect in L1** among dyslexic-readers, with higher accuracy scores **in oral modality** than in written one, while typical-readers were assumed to be equally proficient in L1 word recognition in both modalities, the paradigm necessitating rare words in L1, to avoid ceiling effect and allow accuracy analysis. Furthermore, the counterbalanced order of presentation of modalities across participants allowed us to **exploratory compare the results across sessions**, each participant performing two sessions: one in each modality. A session effect could thus indicate a benefit from one modality over the other.

In order to obtain a control in L1 for each group of Experiment 1, Experiment 2 was proposed to the same five groups of participants: a) French university students, all typical-readers; b) French university students, with a comparison of dyslexic and typical-readers; c)

French middle-school students, all typical-readers; d) French middle-school students, with a comparison of dyslexic and typical-readers; and e) English university students, all typical-readers.

5.2. Method.

5.2.1. Participants.

The same participants as in Experiment 1 took part in this experiment. They performed L1 lexical decision tasks in the same order of presentation of modalities than in Experiment 1.

5.2.2. Stimuli of Lexical Decision Tasks (LDT).

5.2.2.1. French university student groups.

French words were selected from the Lexique 3 database (New, 2006), using the same criteria as in Experiment 1 among English university students, except the frequency range (lower than 5[75] per million in written and in oral forms). From this first list, we then selected 41 words. No word included into the lists of stimuli was an English cognate word (mldTE ≥ 4). Seven percent were monosyllabic, 66% were disyllabic, others were trisyllabic. All words were 4-to-10 letter-long. We then used the software package Wuggy© (Keuleers & Brysbaert, 2010) to create a list of 41 pseudowords matched with the selected words, using the same pairing criteria as in Experiment 1. Appendix 21 page 346 presents the pairings and the complete lists of stimuli.

[75] The aim of Experiment 2a was mainly to analyse accuracy of word recognition. Thus, we chose this specific range of frequency in order to avoid a ceiling effect.

5.2.2.2. French middle-school student groups.

Among the 41 French words selected for French university students, we then selected the 31 more frequent words (frequencies between 1 and 5 per million in oral and written form) for French middle-school students, according to the results of a pilot study. Ten percent were monosyllabic, 55% were disyllabic, others were trisyllabic. Words were 4-to-10 letter-long. The 31 pseudowords matched with the selected words were similar of those for French university students. Appendix 22 page 348 presents the pairings and the complete lists of stimuli.

5.2.2.3. English university student groups.

English words were selected from the CELEX and SUBTLEX-UK databases (Van Der Wouden, 1990; Van Heuven et al., 2014), using the same criteria as in 5.2.2.1 above. We then selected 40 words. No word included into the lists of stimuli was a French cognate word (mldTE ≥ 4). Thirty-eight percent were monosyllabic, 40% were disyllabic, others were trisyllabic. All words were 4-to-10 letter-long. We then used the software package Wuggy© (Keuleers & Brysbaert, 2010) to create a list of 40 pseudowords matched with the selected words, using the same pairing criteria as previously. Appendix 23 page 350 presents the pairings and the complete lists of stimuli.

5.2.3. Procedure.

The procedure was identical to that of Experiment 1.

5.2.4. Statistical analyses.

Data analyses were conducted similarly as in Experiment 1, including Modality (written *vs.* oral), Session (1st *vs.* 2nd) and their interaction[76] as fixed factors.

[76] Experiment 2 being conducted in L1, without any L1-L2 cognate words, it implied a "non-cognate" task only.

5.3. Results.

In order to control in L1 the results obtained in L2 during Experiment 1, and also to further explore the modality effect presented by dyslexic-readers in L2, the aims of Experiment 2 on L1 word recognition were: a) to explore the impact of modality; and b) to exploratory compare the results across sessions.

As previously, the summary of the results would help to follow all the results described below.

5.3.1. French typical-reader university students.

No participant presented a high pseudoword error rate, remaining an Oral-Written-TypFrUniv group of 24 participants and a Written-Oral-TypFrUniv group of 24 participants. We excluded from the analyses five words (*fétu*, *finaud*, *rapt*, *sarment* and *surjet*) following the procedure described in section 3.4 page 67.

5.3.1.1. Discrimination rate (d').

Raw data are presented in Figure 51 below.

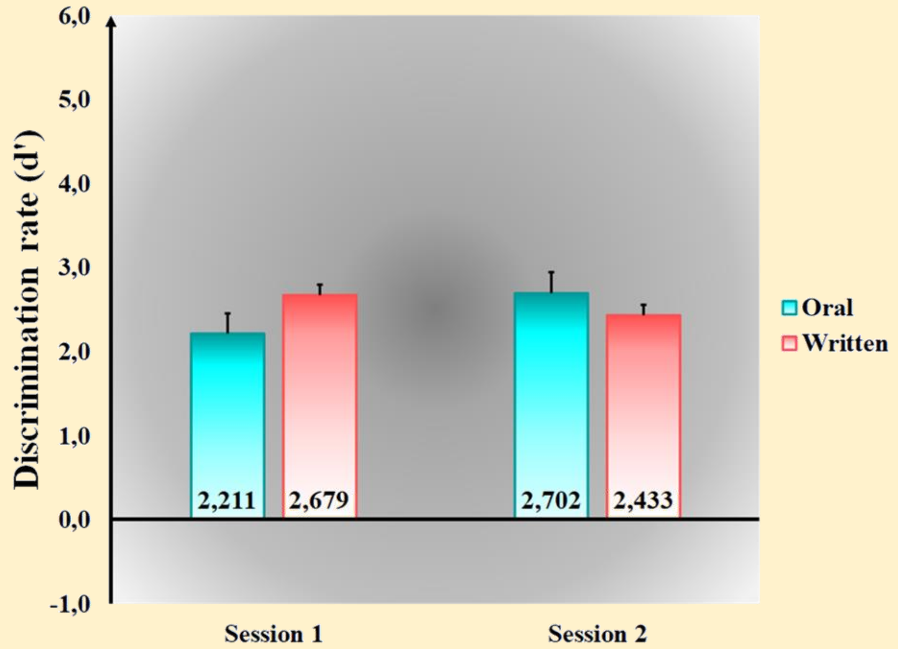

Figure 51. Raw data of d' - French typical-reader university students - Experiment 2.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts[77], and Modality (written vs. oral), Session (1st vs. 2nd) and their interaction as fixed effects (best model according to the AIC: $F(1,46) = 6.503$, $p < .05$). Those fixed effects explained 11% of the variance (marginal $R^2 = .106$).

Interestingly, the interaction between Modality and Session was significant, a session effect (*i.e.*, a difference in d' between sessions, with higher discrimination rates in session 2 compared to session 1) existing in oral modality, but not in written one.

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[78], are reported in Table 32 below.

Table 32. Parameter estimates of the final model fitted to the d' (**and output from the Bayesian analysis in bold**) - French typical-reader university students - Experiment 2.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	2.51	.07	34.68	<.001*	**2.51**	**.07**	**[2.36;2.65]**
Modality	-.10	.09	-1.13	.264	**-.10**	**.09**	**[-.28;.08]**
Session	.12	.09	1.39	.171	**.12**	**.09**	**[-.06;.31]**
Modality x Session	.74	.29	2.55	<.05*	**.73**	**.30**	**[.14;1.33]**

*Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(dprime ~ Modality * Session + (1 | Participant), data = Data_dprime_Exp2a_Frcntrluniv, REML = TRUE)*

5.3.1.2.Accuracy scores (percentage of correct responses for word trials).

Mean accuracy scores of our participants, on word trials only, according to Modality and Session are presented in Figure 52 page 165.

[77] We could not include any random slope – according Modality or Session – because we had only one value of d' for each participant by Modality / Session.

[78] Maximum BF = 1.244, corresponding to the same model formula than those of the final model of LMM (bayes_R^2 = .49, SE = .10, 95% CrI = [.25;.64]).

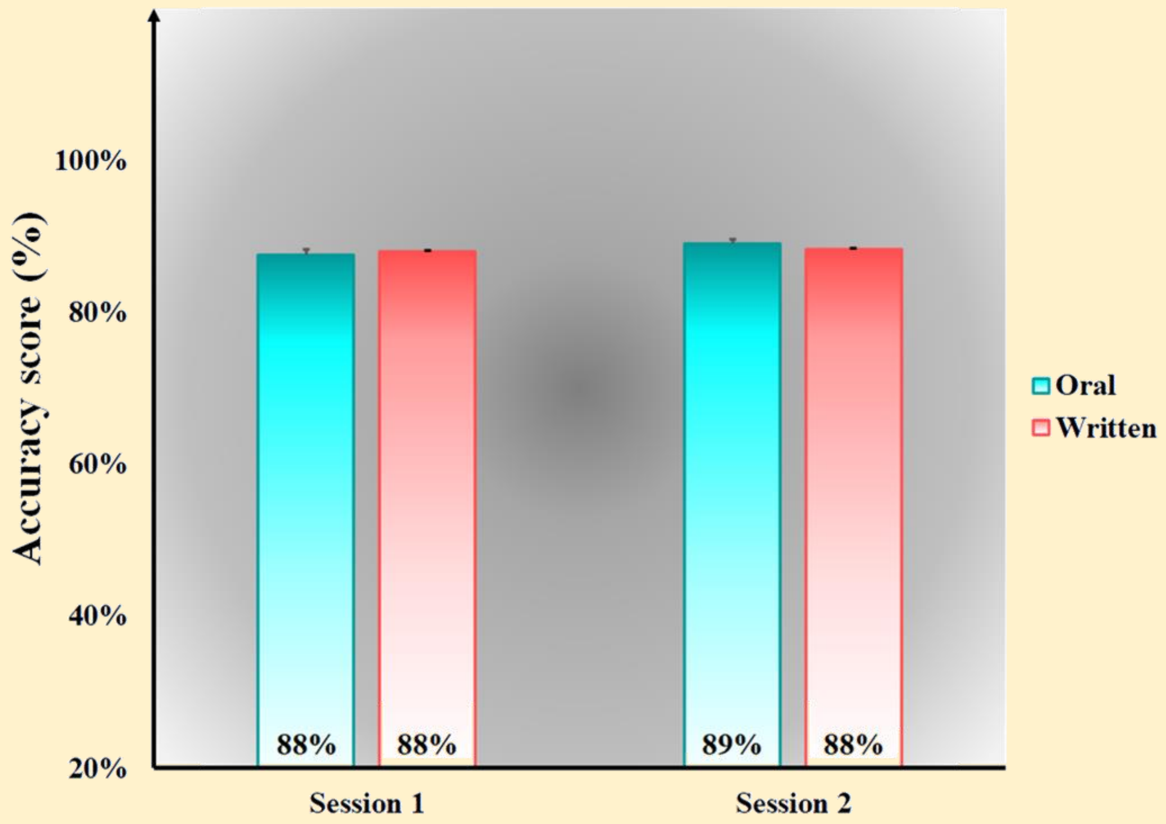

Figure 52. Raw data of Accuracy scores - French typical-reader university students - Experiment 2.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each word included by-participant and by-item random intercepts, and no fixed effect except the intercept (best model according to the AIC). Those fixed and random effects explained 25% of the variance (adjusted $R^2 = .246$).

There was no significant effect.

We tested all possible Bayesian models with the function generalTestBF. The maximum BF was .053, indicating that no model fit better the data than the model including only the intercept. Therefore, there is substantial evidence that this model is the most relevant given the data.

5.3.1.3.Summary of the results.

Table 33 below presents a summary of those results among French typical-reader university students.

Table 33. Summary of the results - French typical-reader university students, Experiment 2.

(M = Modality, S = Session, ✓ = significant effect, ✗ = non-significant effect)

Dependent Variable	M	S	M:S
d'	✗	✗	✓
Accuracy	✗	✗	✗

5.3.2.French university students, both typical and dyslexic-readers.

5.3.2.1.Discrimination rate (d').

Raw data are presented in Figure 53 below.

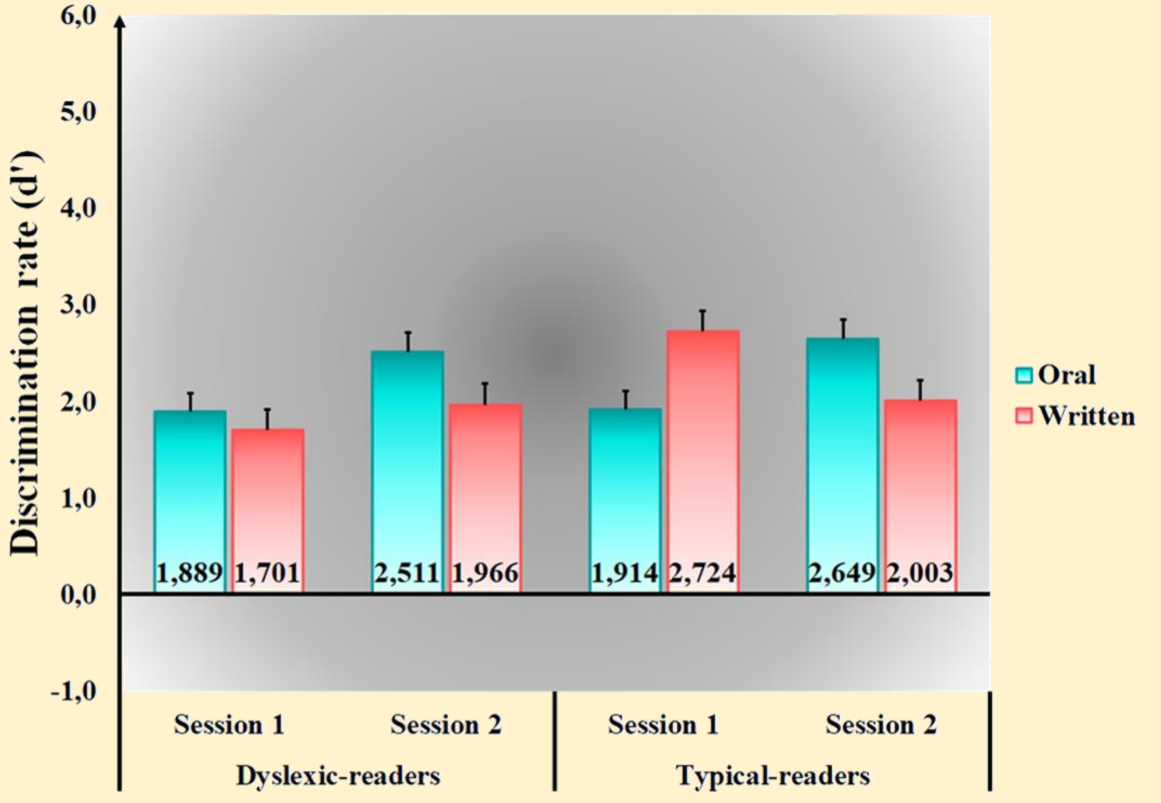

Figure 53. Raw data of d' - French university students, dyslexic and typical-readers - Experiment 2.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts[79], and Modality (written vs. oral), Session (1st vs. 2nd), Group (Typical vs. Dyslexic-readers) and their interactions except the three-way interaction as fixed effects (best model according to the AIC: $F(1,31) = 6.837$, $p < .05$). Those fixed effects explained 26% of the variance (marginal $R^2 = .262$).

Discrimination rates were significantly lower in in Session 1 (2.07, SD = .70) than in Session 2 (2.30, SD = .62). Note that group effect was marginally non-significant, d' seeming to be lower for dyslexic-readers (2.02, SD = .64) than for typical-readers (2.34, SD = .66). Interestingly, the two-way interaction between Modality and Session was significant, a session effect (*i.e.*, a difference in d' between sessions) existing in oral modality, but not in written one. The two-way interaction between Modality and Group was also significant, a modality effect (*i.e.*, a difference in d' between modalities) in favour of the oral one existing among dyslexic-readers, but not among typical-readers. Finally, the two-way interaction between Group and Session was significant, a session effect existing among dyslexic-readers, but not among typical-readers.

The Bayesian analysis demonstrated that the best model that fit the data is the complete model, including the three-way interaction in addition with the fixed effect of the final LMM. We thus fitted the complete model, which highlighted the same effects as the final LMM. Note that the three-way interaction was not significant, explaining why its suppression allowed a better fitting. Note also that the Bayesian analysis showed that the estimates associated with the two-way interactions between Modality and Group, and between Session and Group, were not different from zero. The parameter estimates of the final model fitted to the Response, as well

[79] We could not include any random slope – according Modality or Session – because we had only one value of d' for each participant by Modality / Session.

as the output from the Bayesian analyses corresponding to the best model according to the BF[80], are reported in Table 34 below.

Table 34. Parameter estimates of the complete model fitted to the d' (**and output from the Bayesian analysis in bold**) - French university students, typical and dyslexic-readers - Experiment 2.

Predictors	b	SE b	T	p	**b**	**SE b**	**95% CrI**
(Intercept)	2.17	.09	25.68	<.001*	**2.17**	**.09**	**[1.99;2.34]**
Modality	.14	.11	1.35	.186	**.14**	**.11**	**[-.08;.36]**
Session	.23	.11	2.14	<.05*	**.23**	**.11**	**[.01;.45]**
Group	-.31	.17	-1.81	.081	**-.30**	**.17**	**[-.65;.03]**
Modality x Session	.91	.34	2.68	<.05*	**.92**	**.35**	**[.24;1.62]**
Modality x Group	.45	.21	2.13	<.05*	**.45**	**.23**	**[.00;.90]**
Session x Group	.44	.21	2.07	<.05*	**.44**	**.23**	**[-.01;.89]**
Modality x Session x Group	-1.10	.68	-1.63	.115	**-1.09**	**.71**	**[-2.53;.28]**

*Note: Significant effects at a p < .05 level are marked with a *. Final model formula: lmer(dprime ~ Modality * Session * Group + (1 | Participant), data = Data_dprime_Exp2b_Fruniv_dysctr, REML = TRUE)*

5.3.2.2.Accuracy scores (percentage of correct responses for word trials).

Mean accuracy scores of our participants, on word trials only, according to Modality, Session and Group are presented in Figure 54 page 169.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each word included by-participant random intercepts and by-item random intercepts and random slope considering the Modality, and Modality (written vs. oral) as fixed effect (best model according to the AIC: $\chi^2 = 26.55$, $p < .001$)). Those fixed and random effects explained 45% of the variance (adjusted $R^2 = .453$).

No effect was significant.

We tested all possible Bayesian models with the function generalTestBF. The maximum BF was .898, indicating that no model fit better the data than the model including only the

[80] Maximum BF = 5.472, corresponding to the same model formula than those of the final model of LMM (bayes_R² = .58, SE = .10, 95% CrI = [.34;.72]).

intercept. Therefore, there is substantial evidence that this model is the most relevant given the data.

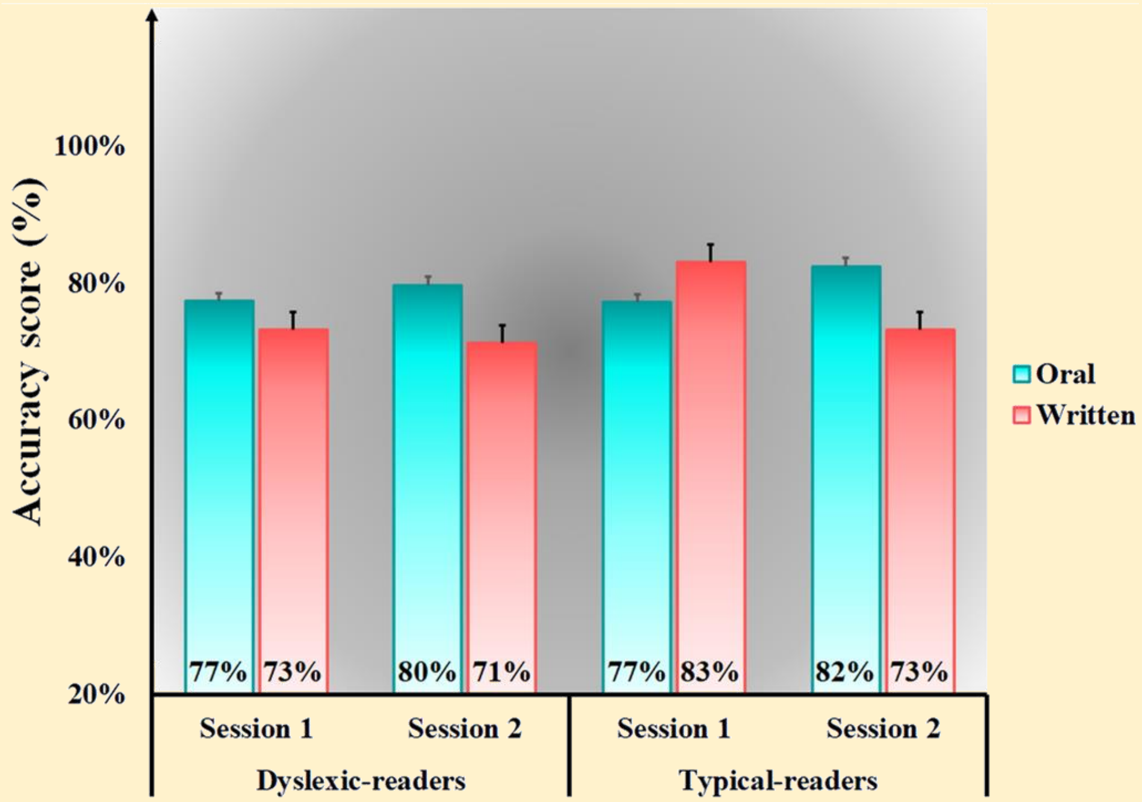

Figure 54. Raw data of Accuracy scores - French university students, typical and dyslexic-readers - Experiment 2.

5.3.2.3. Summary of the results.

Table 35 below presents a summary of the results of Experiment 2 among French university students, typical and dyslexic-readers. The aim being to compare typical and dyslexic-readers, main results concerned group effect and its interaction with other factors.

Table 35. Summary of the results - French university students, dyslexic and typical-readers, Experiment 2.
(M = Modality, S = Session, G = Group, ✓ = significant effect, ✗ = non-significant effect)

Dependent Variable	M	G	S	G:S	M:S	M:G	G:M:S
d'	✗	✓	✗	✗	✓	✗	✗
Accuracy	✗	✗	✗	✗	✗	✗	✗

5.3.3. French typical-reader middle-school students.

We excluded two participants[81] from the analyses, due to their high pseudoword error rates. Finally, we included a remaining Oral-Written-TypFrMid group of 21 participants and a remaining Written-Oral-TypFrMid group of 25 participants. We also excluded from the analysis one word (*rapt*) following the procedure described in section 3.4 page 67.

5.3.3.1. Discrimination rate (d').

Raw data are presented in Figure 55 below.

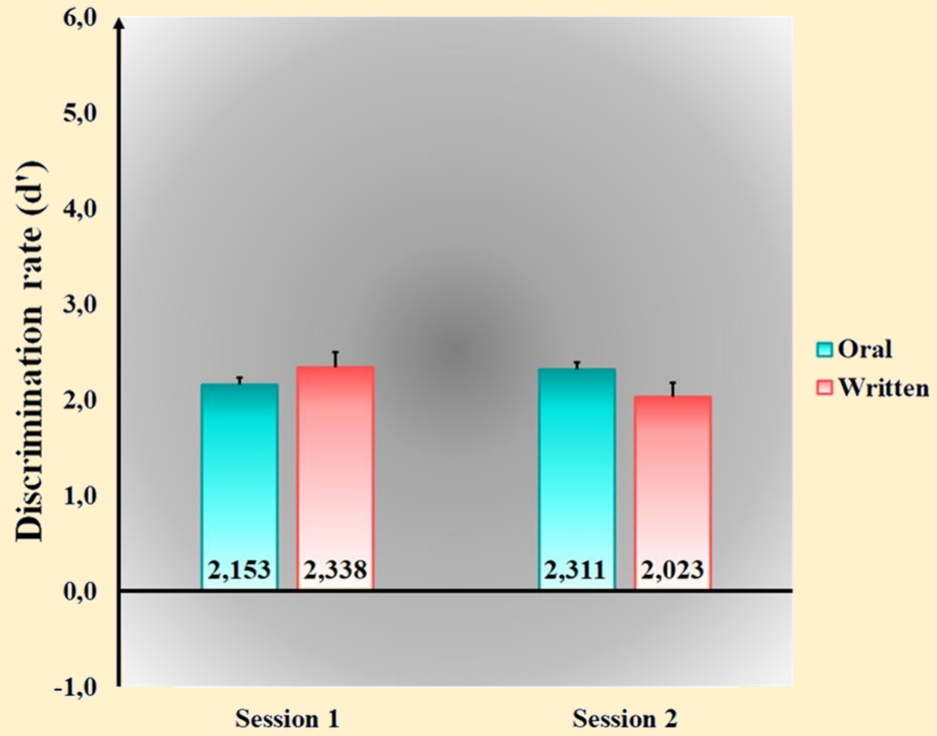

Figure 55. Raw data of d' - French typical-reader middle-school students - Experiment 2.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts[82], and no fixed effect (best model according to the AIC).

[81] We also performed the analyses, without the exclusion of those participants. The pattern of results was identical.

[82] We could not include any random slope – according Modality or Session – because we had only one value of d' for each participant by Modality / Session.

There was no significant effect.

We tested all possible Bayesian models with the function generalTestBF. The maximum BF was .242 that no model fit better the data than the model including only the intercept. Therefore, there is substantial evidence that this model is the most relevant given the data.

5.3.3.2.Accuracy scores (percentage of correct responses for word trials).

Mean accuracy scores of our participants, on word trials only, according to Modality and Session are presented in Figure 56 below.

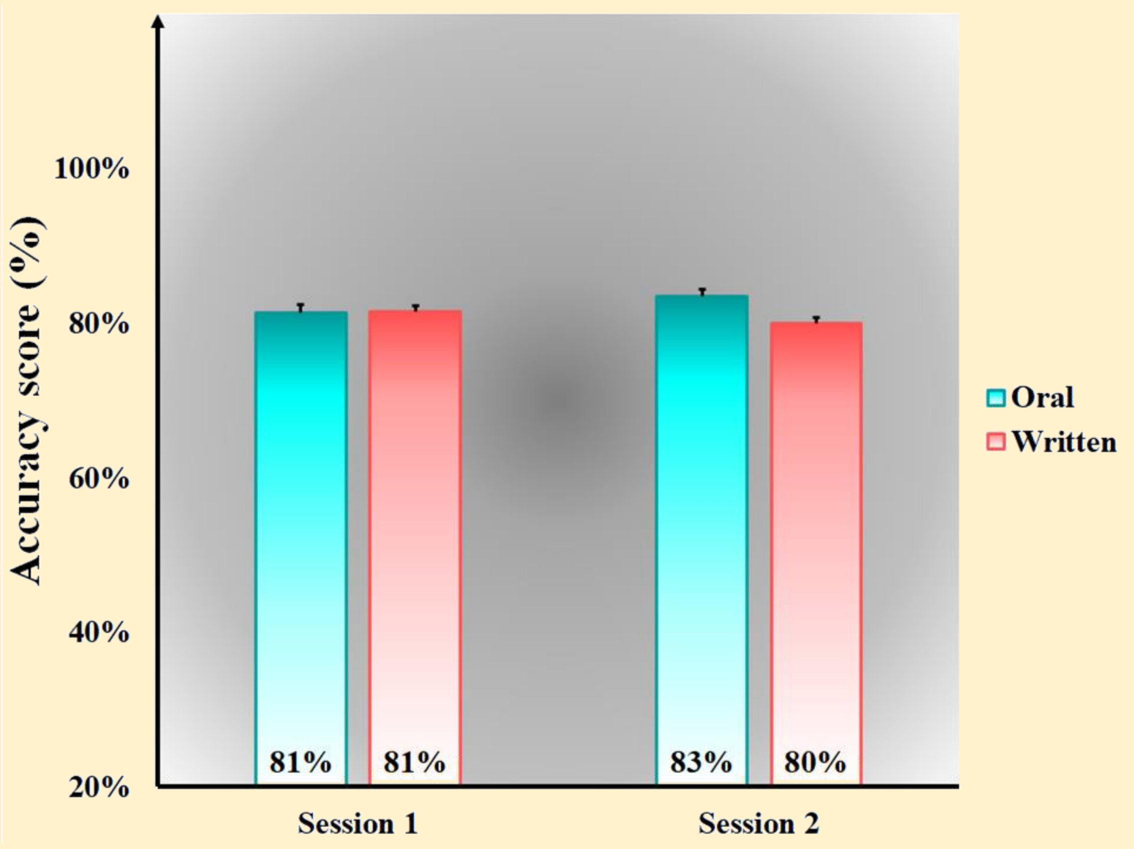

Figure 56. Raw data of Accuracy scores - French typical-reader middle-school students - Experiment 2.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each word included by-participant and by-item random intercepts, and no fixed effect except the intercept (best model according to the AIC).

There was no significant effect.

We tested all possible Bayesian models with the function generalTestBF. The maximum BF was .083, indicating that no model fit better the data than the model including only the intercept. Therefore, there is substantial evidence that this model is the most relevant given the data.

5.3.3.3.Summary of the results.

Table 36 below presents a summary of the main results of Experiment 2 among French typical-reader middle-school students.

Table 36. Summary of the results - French typical-reader middle-school students – Experiment 2.

(M = Modality, S = Session, ✓ = significant effect, ✗ = non-significant effect)

Dependent Variable	M	S	M:S
d’	✗	✗	✗
Accuracy	✗	✗	✗

5.3.4.French middle-school students, both typical and dyslexic-readers.

5.3.4.1.Discrimination rate (d’).

Raw data are presented in Figure 57 page 173.

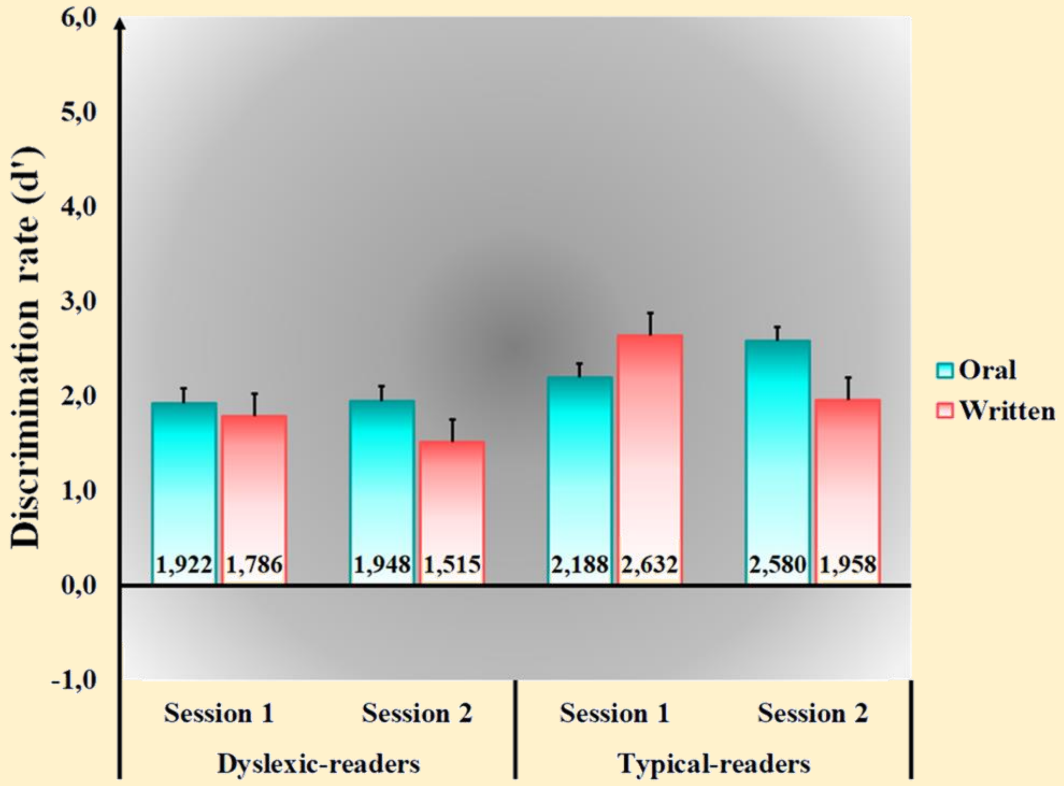

Figure 57. Raw data of d' - French middle-school students, dyslexic and typical-readers - Experiment 2.

Final model formula:

The final LMM fitted to the d' of each participant included by-participant random intercepts[83], and Modality (written vs. oral), Session (1st vs. 2nd), Group (Typical vs. Dyslexic-readers) and the two-way interaction between Modality and Session as fixed effects (best model according to the AIC: $F(1,31) = 12.089$, $p < .01$). Those fixed effects explained 30% of the variance (marginal $R^2 = .302$).

Discrimination rates were significantly lower in written modality (1.959, SD = .72) than in oral one (2.153, SD = .45), and for dyslexic-readers (1.788, SD = .55) than for typical-readers (2.324, SD = .54). Interestingly, the two-way interaction between Modality and Session was significant, a session effect (*i.e.*, a difference in d' between sessions) existing in written modality, with higher d' in Session 1 (2.209, SD = .79) than in Session 2 (1.736, SD = .60, $t(27.878) = 1.953$, $p < .05$), but not in oral modality ($t(26.309) = -1.341$, $p = .096$).

[83] We could not include any random slope – according Modality or Session – because we had only one value of d' for each participant by Modality / Session.

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[84], are reported in Table 37 below.

Table 37. Parameter estimates of the final model fitted to the d' (**and output from the Bayesian analysis in bold**) - French middle-school students, typical and dyslexic-readers - Experiment 2.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	2.07	.08	26.77	<.001*	**2.06**	**.08**	**[1.91;2.22]**
Modality	.19	.09	2.10	<.05*	**.19**	**.09**	**[.00;.37]**
Session	-.13	.09	-1.48	.149	**-.13**	**.09**	**[-.32;.05]**
Group	.54	.15	3.48	<.01*	**.53**	**.16**	**[.22;.85]**
Modality x Session	.68	.31	2.21	<.05*	**.69**	**.32**	**[.04;1.32]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(dprime ~ Modality + Session + Group + Modality:Session + (1 | Participant), data = Data_dprime_Exp2d_Frcoll_dysctr, REML = TRUE)

5.3.4.2.Accuracy scores (percentage of correct responses for word trials).

Mean accuracy scores of our participants, on word trials only, according to Modality, Session and Group are presented in Figure 58 page 175.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each word included by-participant random intercepts and by-item random intercepts and random slope considering the Modality, and Modality (written vs. oral) as fixed effect (best model according to the AIC: $\chi^2 = 8.99$, $p < .05$)). Those fixed and random effects explained 43% of the variance (adjusted $R^2 = .429$).

Accuracy scores were significantly lower in written modality (76%, SD = 43) than in oral one (80%, SD = 40).

[84] Maximum BF = 220.691, corresponding to the same model formula than those of the final model of LMM (bayes_R^2 = .62, SE = .09, 95% CrI = [.41;.75]).

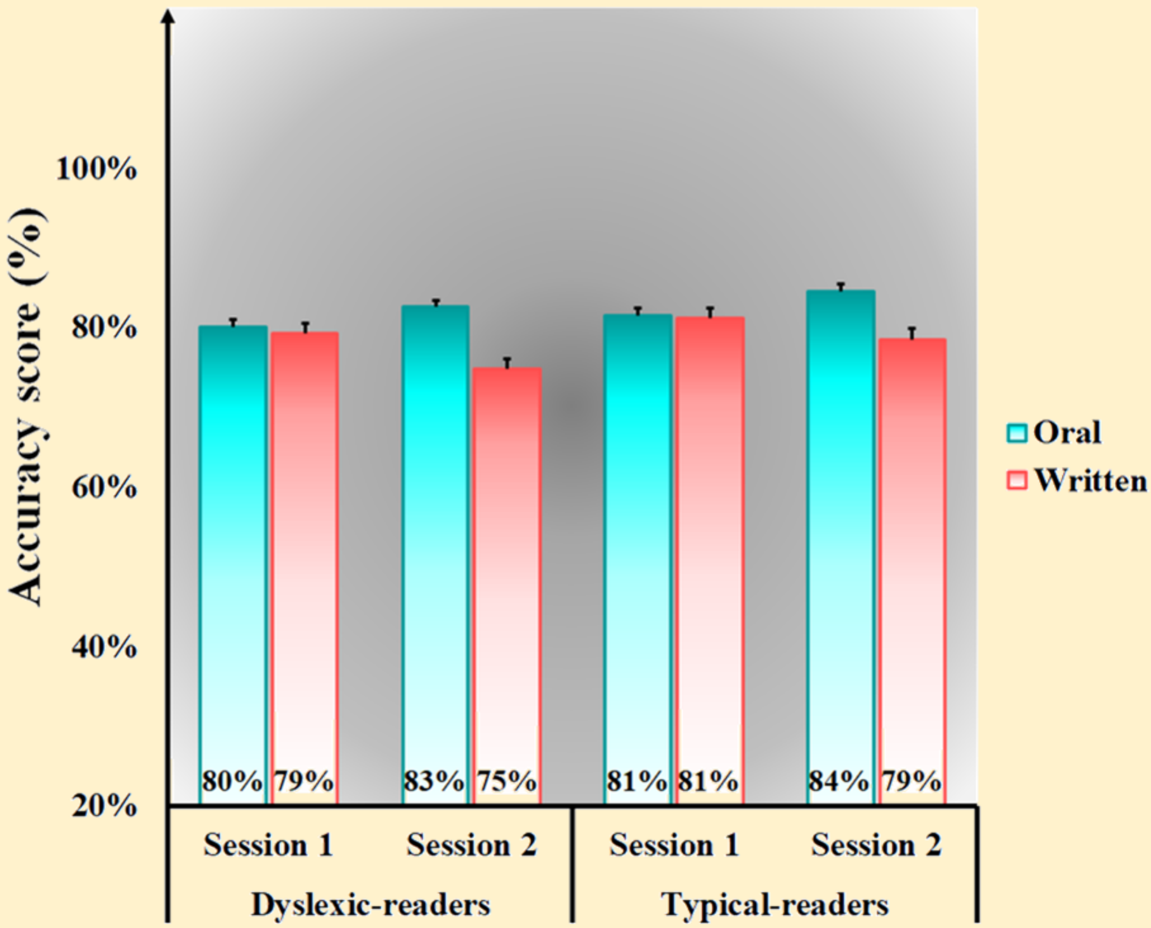

Figure 58. Raw data of Accuracy scores - French middle-school students, dyslexic and typical-readers - Experiment 2.

We tested all possible Bayesian models with the function generalTestBF. The maximum BF was .350, indicating that no model fit better the data than the model including only the intercept. Therefore, there is substantial evidence that this model is the most relevant given the data. By the way, the Bayesian analysis demonstrated that the estimate associated with Modality was not different from zero. The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[85], are reported in Table 38 page 176.

[85] Maximum BF = 314,266,428, corresponding to the same model formula than those of the final model of GLMM.

Table 38. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - French middle-school students, typical and dyslexic-readers - Experiment 2.

Predictors	B	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	2.04	.36	5.61	<.001*	**2.07**	**.40**	**[1.30;2.91]**
Modality	.40	.19	2.12	<.05*	**.39**	**.21**	**[-.01;.82]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(dprime ~ Modality + (1 | Participant) + (1 + Modality | Item), data = Data_LDT_Exp2d_Frcoll_dysctr, REML = TRUE)

5.3.4.3.Summary of the results.

Table 39 below presents a summary of the results of Experiment 2 among French middle-school students, typical and dyslexic-readers. The aim being to compare typical and dyslexic-readers, main results concerned group effect and its interaction with other factors.

Table 39. Summary of the results - French middle-school students, dyslexic and typical-readers.
(M = Modality, S = Session, G = Group, ✓ = significant effect, ✗ = non-significant effect)

Dependent Variable	M	G	S	M:S	M:G	M:S:G
d’	✗	✓	✗	✓	✗	✗
Accuracy	✗	✗	✗	✗	✗	✗

5.3.5.English typical-reader university students.

There was no participant with a high pseudoword error rate. However, we needed to exclude one participant, due to technical issue. Finally, we included a remaining Oral-Written-TypEnUniv group of 18 participants and a remaining Written-Oral-TypEnUniv group of 20 participants. We also excluded from the analyses one word (*shale*) following the procedure described in section 3.4 page 67.

5.3.5.1.Discrimination rate (d’).

Raw data are presented in Figure 59 page 177.

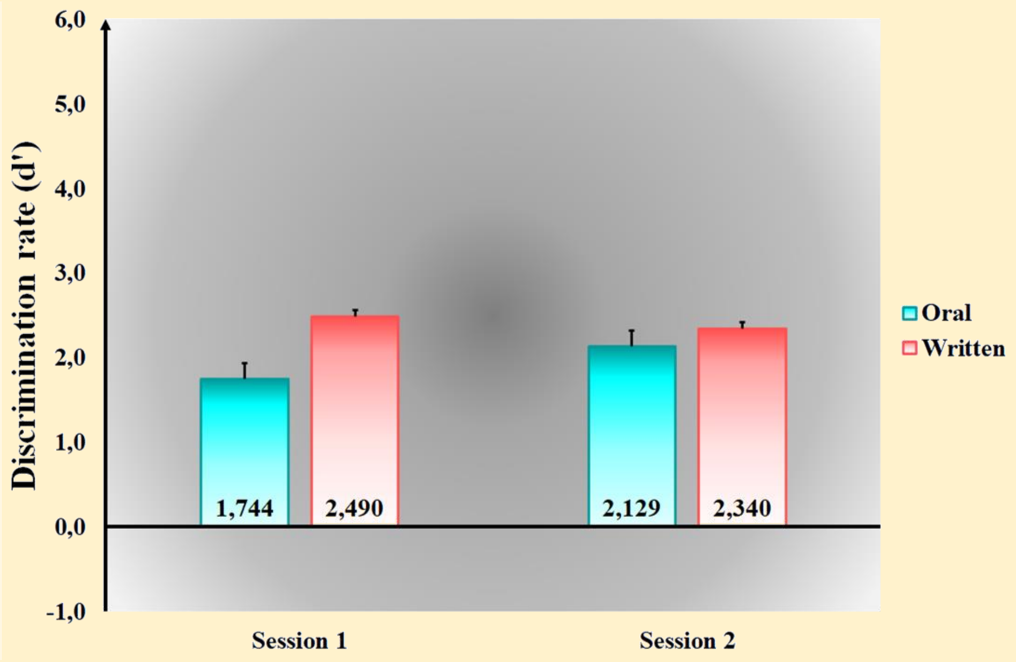

Figure 59. Raw data of d' - English typical-reader university students - Experiment 2.

Final model formula:

The final LMM fitted to the d’ of each participant included by-participant random intercepts[86], and Modality (written vs. oral), Session (1st vs. 2nd) and their interaction as fixed effects (best model according to the AIC: $F(1,36) = 5.478$, $p < .05$). Those fixed effects explained 26% of the variance (marginal $R^2 = .263$).

Discrimination rates were significantly lower in oral modality (1.947, SD = 41) than in written one (2.419, SD = .55). Interestingly, the interaction between Modality and Session was significant, a session effect (*i.e.*, a difference in d’ between sessions) existing in oral modality ($t(32.066) = -3.204$, $p < .01$), but not in written one ($t(35.827) = .838$, $p = 408$).

The parameter estimates of the final model fitted to the d’, as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[87], are reported in Table 40 page 178.

[86] We could not include any random slope – according Modality or Session – because we had only one value of d’ for each participant by Modality / Session.

[87] Maximum BF = 450.752, corresponding to the same model formula than those of the final model of LMM (bayes_$R^2 = .36$, SE = .09, 95% CrI = [.19;.55]).

Table 40. Parameter estimates of the final model fitted to the d' (**and output from the Bayesian analysis in bold**) - English university students, typical-readers - Experiment 2.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	2.18	.06	38.04	<.001*	**2.18**	**.06**	**[2.06;2.29]**
Modality	-.48	.10	-4.77	<.001*	**-.48**	**.10**	**[-.68;-.28]**
Session	.12	.10	1.17	.248	**.12**	**.10**	**[-.08;.32]**
Modality x Session	.54	.23	2.34	<.05*	**.53**	**.24**	**[.08;1.00]**

*Note: Significant effects at a p < .05 level are marked with a ⁎. Final model formula: lmer(dprime ~ Modality * Session + (1 | Participant), data = Data_dprime_Exp2e_Engluniv_ctr, REML = TRUE)*

5.3.5.2.Accuracy scores (percentage of correct responses for word trials).

Mean accuracy scores of our participants, on word trials only, according to Modality and Session are presented in Figure 60 below.

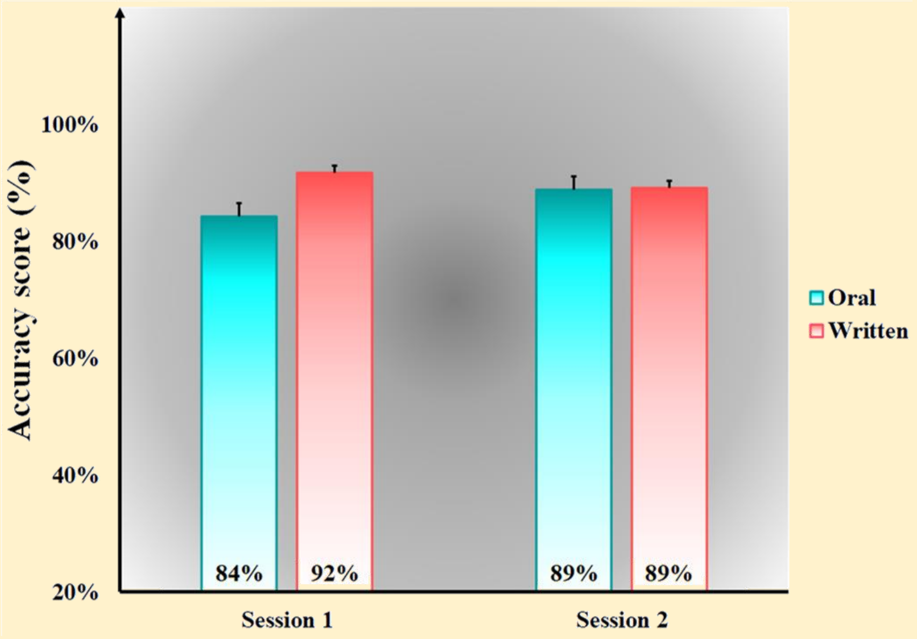

Figure 60. Raw data of Accuracy scores - English typical-reader university students - Experiment 2.

Final model formula:

The final GLMM fitted to the Response (correct vs. incorrect) of each participant for each word included by-participant random intercepts, and by-item random intercepts and random slope considering the Modality, and Modality (written vs. oral) as fixed effect (best model according to the AIC: $\chi^2 = 51.985$, $p < .001$). Those fixed and random effects explained 24% of the variance (adjusted $R^2 = .240$).

Accuracy scores were significantly lower in oral modality (87%, SD = 34) than in written one (91%, SD = 29).

The parameter estimates of the final model fitted to the Response, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[88], are reported in Table 41 below.

Table 41. Parameter estimates of the final model fitted to the Response (**and output from the Bayesian analysis in bold**) - English university students, typical-readers - Experiment 2.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	2.85	.26	11.19	<.001*	**2.91**	**.29**	**[2.35;3.50]**
Modality	-.60	.26	-2.32	<.05*	**-.61**	**.30**	**[-1.21;-.03]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(dprime ~ Modality + (1 | Participant) + (1 + Modality | Item), data = Data_LDT_Exp2e_Engluniv_ctr, REML = TRUE)

5.3.5.3. Summary of the results.

Table 42 below presents a summary of the main results of Experiment 2 among English typical-reader university students.

Table 42. Summary of the results of Experiment 2 – English university students, typical-readers.
(M = Modality, S = Session, ✓ = significant effect, ✗ = non-significant effect)

Dependent Variable	M	S	M:S
d'	✓	✗	✓
Accuracy	✓	✗	✗

5.4. Discussion.

Experiment 2 aimed to control whether the modality effect highlighted on L2 word recognition in Experiment 1 exists also on L1 word recognition, notably among dyslexic-readers (but also among typical-readers, in order to have a control in L1 for each of our group

[88] Maximum BF = 8.876, corresponding to the same model formula than those of the final model of GLMM.

of participants in Experiment 1). Experiment 2 was therefore proposed to the same five groups of participants of Experiment 1. As for the previous experiment, we will propose in this section a brief summary of the results of each group and their simple interpretation: see Table 43 below. This table contains the main results concerning Accuracy scores[89] for each group. Note that the direction of effects is not indicated here, but will be discussed in the following interpretation. A theoretical discussion concerning all experiments will be proposed at the end of this manuscript.

Table 43. Summary of the results on Accuracy scores - Experiment 2 - all groups.

(Fr = French, En = English, U = University students, M = Middle-schoolers, Typ = Typical-readers, Dys = Dyslexic-readers, M = Modality, G = Group, S = Session, ✓ = significant effect, ✗ = non-significant effect)

Group	M	S	G	M:S	M:G	G:S	G:M:S
TypFrU	✗	✗	NA	✗	NA	NA	NA
DysFrU	✗	✗	✗	✗	✗	✗	✗
TypFrM	✗	✗	NA	✗	NA	NA	NA
DysFrM	✗	✗	✗	✗	✗	✗	✗
TypEnU	✓	✗	NA	✗	NA	NA	NA

5.4.1. First hypothesis: No modality effect on L1 word recognition among typical-readers.

As anticipated, Experiment 2 highlighted no modality effect on L1 word recognition accuracy among French typical-reader university students. Critically, French typical-reader middle-schoolers presented exactly the same pattern of results than their adult pairs. This is congruent with the results of Wolf et al. (2021), who also failed to observe a modality effect on L1 word recognition accuracy, concerning difficult words (*i.e.*, rare words).

[89] We decided to present here only the effects on Accuracy scores, for more efficacy and conciseness.

Surprisingly, English native-speakers showed a modality effect in L1 word recognition, with higher accuracy scores for L1 English written words compared to L1 English spoken words, concerning rare words. This consists in a major finding, indicating that English native-speakers presented the same type of modality effect in favour of the written modality in English than that highlighted in English as an L2 among French native-speakers (see Experiment 1). This modality effect could be linked with different activation mechanisms depending on the modality: lexical in written modality and sub-lexical in oral one. However, this effect was absent in French as an L1 among French native-speakers in the current experiment, as well as in Dutch among Dutch native-speakers in previous studies (see Wolf et al., 2021). Therefore, everything happened as if English language features make more difficult spoken word recognition than French language features do. This could be a consequence of the huge orthographic inconsistency of English language, compared to French orthography, less opaque than English one (Seymour et al., 2003). This could also be due to some inconsistency in the way each individual pronounces a word, depending on his/her geographical origin, this experiment involving English university students in Scotland only. Further research on this latter hypothesis is needed.

5.4.2.Second hypothesis: Existence of a modality effect, in favour of the oral one, on L1 word recognition among dyslexic-readers.

Surprisingly, considering the comparison between dyslexic and typical-reader university students, we observed exactly the same pattern of results in each group. In addition, we found no effect of group on both word-pseudoword discrimination rate and word recognition accuracy. This was unexpected. Actually, this lack of effect is not entirely consistent with the dual-route cascaded model of "visual word recognition and reading aloud" (Coltheart et al., 2001). According to this model, the lexical pathway establishment is compromised for dyslexic-readers, due to their phonological deficit, altering their ability to access phonological representations from written words (Law et al., 2017; Norton et al., 2015; Peterson & Pennington, 2015; Ramus, 2010; Ramus & Szenkovits, 2008; Snowling, 1981; Ziegler & Goswami, 2006), and thus impairing reading *via* the phonological pathway during the learning of reading (Coltheart et al., 2001; Gangl et al., 2017). Nevertheless, this finding is congruent with the equal vocabulary breadth and high vocabulary depth of dyslexic-reader university students, compared to typical-reader university students, highlighted by Cavalli et al. (2016), which consisted in a compensatory strategy of dyslexic-readers to develop their reading skills and manage the written stimuli intensive exposure during university courses.

Interestingly, and in contradiction with the hypothesis formulated above, the comparison between dyslexic and typical-reader middle-school students highlighted the same absence of a group effect on word recognition accuracy, even though a group effect was found on word-pseudoword discrimination rate. This finding requires to be further analysed, notably in the light of latencies. Indeed, this lack of modality effect in favour of the oral one among dyslexic-readers on L1 word recognition accuracy raised the question of its existence on L1 word recognition latencies, which could not be properly analysed with the current paradigm. Indeed, considering their written stimuli processing difficulties, we anticipated them to be in trouble for L1 written word recognition. L1 spoken word recognition would be less difficult for them, even if some inconsistent words could hamper their recognition, given the phonological deficit of dyslexic-readers. Moreover, given that most of dyslexic-reader participants report a speech therapy for their difficulties, they could present some effects limited to latencies. However, the paradigm used in the current experiment did not allow the analysis of latencies, given that item selection was performed with the aim of accuracy analysis. We thus selected rare L1 words, in order to avoid a ceiling effect, precluding precise latency analysis.

5.4.3. Exploratory analysis of the session effect.

Experiment 2 demonstrated the absence of session effect in all groups. Therefore, hearing an L1 word activates a lexical representation, which students did not need to use for secondary written word recognition. Therefore, when they saw the same word they had just heard, they recognized it as if they had not heard it before. Likewise, their lexical representation activated when they saw a written L1 word do not help its auditory recognition. This indicates that both spoken and written word recognition are so efficient in L1 that they do not need additive cues to be accurate.

5.4.4. Limitations.

There are some limitations to this study, such as the fact that the experimental design used in Experiments 1 and 2 did not allow a complete analysis of the modality effect on latencies which would be interesting to understand L2 word processing mechanisms properly and to determine why both French and English languages presented crucial differences during L1 word recognition (see section 5.4.1 page 180). Indeed, the lack of session effect in terms of accuracy raised the question of the existence of this effect on latencies, which are more precise than accuracy and could reveal the particular difficulties of dyslexic-readers with a history of speech therapy. However, it is technically impossible to purely analyse accuracy and latencies with the same paradigm, latency analysis needing a ceiling effect, while accuracy analysis necessitates the absence of floor and/or ceiling effect. It is therefore necessary to conduct further experiments to analyse L1 and L2 word recognition latencies across sessions.

5.5. Conclusion.

In conclusion, our results argued in favour of the absence of modality effect in French as an L1 among French typical-readers, either university or middle-school students, concerning rare words. More, language features (notably English language orthographic inconsistency) seem crucial, given that English native-speakers presented a modality effect on L1 word recognition. Critically, our results were not completely consistent with the dual-route cascaded model of visual word recognition and reading aloud (Coltheart et al., 2001) concerning L1 word recognition difficulties in written modality among dyslexic-readers, justifying the need of further exploration of the question of modality effect in L1, notably through an analysis of L1 word recognition latencies.

The experimental design used in Experiments 1 and 2 not allowing a complete analysis of the modality effect on latencies, we have implemented a second experimental design, constituting Experiments 3 (in L2) and 4 (in L1).

Chapter 6. Experiment 3: Impact of cross-modal repetition on L2 word recognition latencies

6.1. Introduction

Experiment 1 highlighted a modality effect on L2 word recognition accuracy, indicating that orthographic lexical representations in L2 were easier to activate than phonological ones, among intermediate proficiency late bilinguals. But no session effect was demonstrated, thus no benefit from one modality over the other. However, the experimental design did not allow a complete analysis of this effect. Indeed, we decided to analyse mainly L2 word recognition accuracy, and therefore chose specific items to avoid floor and ceiling effects. This precluded a precise analysis of latencies, which would be of major interest to evaluate the availability of each representation, and notably the fact that the recognition of an L2 word in one modality could pre-activate the representation of this word in the other modality. We have therefore implemented another experimental design in order to overcome this lack. Experiment 3 aimed to evaluate the robustness of the links between L2 orthographic and phonological lexical representations. To do so, Experiment 3 evaluated the extent to which cross-modal repetition of words impact L2 word recognition latencies.

Due to the impossibility to conduct face-to-face experimentations during the COVID-19 pandemic, this experiment had been implemented online, *via* the Psytoolkit platform (Stoet, 2010, 2017). Moreover, French schools being closed during the lockdown, and no longer accepting outside contributors when they reopened, this experiment was proposed to university students only, in France and in Scotland. Finally, these particular conditions reduced our ability to recruit dyslexic individuals.

Experiment 3 was thus conducted among three groups of participants: a) French university students, all typical-readers; b) French university students, with a comparison of dyslexic and typical-readers; and c) English university students, all typical-readers.

Experiment 3 aimed to evaluate the robustness of the links between L2 orthographic and phonological lexical representations among the population of intermediate proficiency bilinguals, through an analysis of latencies. Because cognate words modulate word recognition latencies differently in both modalities, Experiment 3 included a non-cognate task only. We designed a paradigm, aiming to evaluate the impact of cross-modal repetition of L2 words on their recognition latencies. As in Experiment 1, this paradigm involved two lexical decision tasks, one in each modality, performed one after the other, and with a counterbalanced order of presentation of modalities across participants. The first lexical decision task, whatever the corresponding modality, consisted in an exposition phase, while the second one was the test phase. In addition, in the current experiment, stimuli list of the test phase included words repeated or not across modalities (*i.e.*, included or not in the exposition phase), each for a half. We expected to highlight an effect of the cross-modal repetition of L2 words on their recognition latencies, with **lower latencies for repeated words, compared to non-repeated words, among typical-readers**. Moreover, we expected to observe this effect **for the test phase in written modality** more than that in oral one. Indeed, the modality effect observed in Experiment 1 suggests an easier activation of L2 orthographic lexical representations, compared to phonological ones. Therefore, the recognition of an L2 spoken word was anticipated to lead to a pre-activation of its associated orthographic representation, easy to access. Furthermore, as this type of design requires to select more frequent items, in order to ensure a maximum of items to be known, we expected **not to observe such an L2 proficiency effect** than that of Experiment 1. Finally, due to their written stimuli processing difficulties and phonological deficit, **dyslexic-readers** were anticipated to be **less sensitive to this cross-modal repetition.**

6.2. Method.

6.2.1. Participants.

6.2.1.1. French university student groups.

The two groups of French university students were recruited thanks to the Psytoolkit platform (Stoet, 2010, 2017) from several French universities. All of them were native-speakers of French, having learned English as an L2 in a school context in France. They reported no hearing problems and normal or corrected-to-normal vision. They were paid for their participation in this project.

We thus recruited a group of 94 participants, from which none of them reported any kind of learning impairment. Three participants with baseline reaction times longer than the others, according to the Deary-Liewald Reaction Time task background test (with respectively a mean choice reaction time of 1119 ms, 923 ms and 870 ms, the average choice reaction time of other participants being of 455 ms), were excluded *a posteriori* from the analyses. The 91 remaining participants constituted the group of French typical-reader university students, randomly assigned to an exposition phase in one modality, either oral or written, and thus to a test phase in the other modality, each of a half. Finally, 47 participants performed the test phase in the written modality (written-ExpFrUniv), and 44 in the oral modality (oral-ExpFrUniv). Demographic data of those participants are available in Appendix 24 page 352.

We also recruited 20 other participants from the same population. All of them reported a diagnostic of developmental dyslexia, but no other impairment. Among the 91 typical-reader participants, we then selected 20 participants matched with dyslexic-readers on age, gender, laterality, socio-economic status, age of acquisition of English, level of proficiency in English, modality of the test phase, mean simple reaction time (SRT) and mean choice reaction time

(CRT – see for these tests). Appendix 25 page 354 presents the pairings between both groups (typical and dyslexic-readers). Note that 7 dyslexic-readers performed the test phase in the written modality (written-DysFrUniv, matched with 8 typical-readers performing the test phase in written modality also: written-ExpFrUnivMatched), and 13 dyslexic-readers performed the test phase in oral modality (oral-DysFrUniv, matched with 12 typical-readers performing the test phase in oral modality also: oral-ExpFrUnivMatched).

6.2.1.2.English university student groups.

Finally, we recruited a group of 56 participants from the University of Dundee (Scotland, United Kingdom), who received course credits for their participation. However, 35 participants needed to be excluded from the analyses *a posteriori*, due to their high pseudoword error rates. Therefore, we decided finally not to include this group into the analyses.

6.2.2.Questionnaires.

We administered to the French typical-reader university students the Adult Reading Habits Questionnaire described above (see section 3.2.2 page 63). We administered the same questionnaire to the French dyslexic-reader university students. Appendix 26 page 355 presents the pairings between groups. Dyslexic and typical-readers were similar concerning the exposures to French and English languages. Of course, dyslexic-readers had more difficulties learning to read in primary school and reading currently than typical-readers.

6.2.3.Background tests.

The same background tests as in Experiments 1 and 2 cannot be administered to the participants, in the digital version of this experiment. Thus, firstly, we administered the English Dialang test: Dialang Level (score out of 1,000).

Secondly, the participants performed the Deary-Liewald Reaction Time task, in order to evaluate their baseline reaction time (Deary et al., 2011). This is a reaction time programme including two tasks: the simple reaction time task (SRT) and the four-choice reaction time task (CRT). For the SRT, a white box is placed in the centre of a blue screen. A cross appears randomly in the box. The participants should press the space bar as quickly as they can each time a cross appears, using their preferred hand. There were eight practice trials, and then the test session including 40 trials. For the CRT, four white boxes are placed in one line in the centre of the blue screen. A cross appears randomly in one of these boxes. The participants should press the correct key corresponding to that box as quickly as they can each time a cross appears, using their middle and index fingers of both hands. The corresponding keys are, for boxes from the left to the right, “D”, “F”, “J” and “K”. There were eight practice trials, and then the test session including 40 trials.

Appendix 27 page 360 presents the results of those tests, as well as the statistics comparing the different groups of French university students.

6.2.4. Stimuli of the English Lexical Decision Tasks (LDT).

English words were selected from the draft database of the APPREL2 ANR project presented previously, using the following criteria: frequency between 200 and 3000[90] per million in written form, frequency between 200 and 3000 per million in oral form according to the SUBTLEX-UK© database[91] (Van Heuven et al., 2014), 3-to-12 letter-long, no homophones or homographs (in English and also in French), no plurals or conjugated forms, non-cognate words (mldTE $\geq$ 4) only.

[90] The aim of Experiment 3 was mainly to analyse latencies of word recognition. Thus, we chose this specific range of frequency in order to be able to analyse latencies properly.

[91] It existed no database providing lexical frequencies in oral form for L2 learners. That is why we decided to use this database, commonly used for experiments among monolinguals.

We then selected from this first list 120 non-cognate words (mldTE ≥ 4). Fourty-four percent were monosyllabic, 44% were disyllabic, others were trisyllabic. All words were 4-to-10 letter-long. We then used the software package Wuggy© (Keuleers & Brysbaert, 2010) to create a list of 120 pseudowords matched with the selected words, using the same pairing parameters as previously.

Finally, we divided the list of 120 pairs of words and pseudowords into three groups (A, B and C) of 40 pairs of words and pseudowords. We checked the pairings between all those stimuli. Appendix 28 page 362 presents the complete pairings and the lists of stimuli.

6.2.5. Procedure.

For each participant, two lists of 80 pairs of words and pseudowords were created. One group of 40 pairs of words and pseudowords was repeated in both lists, the two other groups were used in one list only. For example, the two lists could be the following:

- List 1: Groups A and B;
- List 2: Groups A and C.

One list was used for the exposition phase, the second for the test phase, each in one modality.

Each participant therefore performed two phases of LDT, one in each modality, using one of the preceding lists. There was a short break within each phase. The first phase was considered as an exposition to 80 pairs of words and pseudowords. The second phase consisted in the test phase, to determine if word recognition latencies depend on the fact that items were pre-activated, through the cross-modal repetition, during the exposition phase.

For the written modality LDT, stimuli were presented in uppercase in Courier New (24-point font size). They appeared as black characters on a white background on the screen. The sequence of each trial was the following: (1) a fixation cross appeared in the centre of the screen for 200 milliseconds; (2) a series of hashes (#########) appeared in the centre of the screen for 500 milliseconds; (3) a stimulus (word or pseudoword) was presented in the centre of the screen until the participant's answer or for 3,000 milliseconds maximum if no response was made. The inter-stimuli interval was 200 milliseconds long.

For the oral modality LDT, the apparatus was exactly the same as for the visual one, but stimuli were played through speakers or headphones (depending on the participant preference, a test of sound volume being done by the Psytoolkit platform before the experiment starts). The procedure was identical to that used in the visual one, except that the stimuli were played binaurally.

Each LDT was preceded by practice trials.

Participants responded on their keyboards, using their index fingers to press the "A" and "P" key. The index finger of their preferred hand corresponded to the response "Word"; the index finger of their non-dominant hand corresponded to the response "Pseudoword". The Psytoolkit platform recorded two dependent variables: response (correct or not) and reaction time (in milliseconds) for correct trials. Those dependent variables were as precisely recorded as during face-to-face experiments, as demonstrated by Kim et al. (2019 ; see also Hilbig, 2016).

6.2.6. Statistical analyses.

Data analyses were conducted as mentioned in Chapter 4.4. The aim of Experiment 3 was the analyse of latencies, during the test phase. Each participant performing this phase in one modality only, either written or oral, we decided to analyse latencies, in both modalities separately[92], with mixed-effect modelling and Bayesian statistics, including Item-type (repeated

[92] In order to analyse the cross-modal repetition effect in a within-participant design.

vs. non-repeated), L2-Proficiency (Dialang Level out of 1,000) and their interactions as fixed factors.

For the comparison between matched French typical and dyslexic-reader university students, we performed the same analysis including Group (Typical *vs.* Dyslexic-readers) and its interactions with other factors into all analyses.

6.3. Results.

The aim of Experiment 3 on L2 word recognition was to evaluate the robustness of the links between L2 orthographic and phonological representations among the population of intermediate proficiency bilinguals, through an analysis of the impact of cross-modal repetition of words on L2 word recognition latencies.

As previously, the summary of the results would help to follow all the results described below.

6.3.1. French typical-reader university students.

We excluded 16 participants[93] from the analyses, due to their high pseudoword error rates, remaining a group of 42 participants performing the test phase in the written modality and a group of 33 participants performing the test phase in the oral modality.

6.3.1.1. Latencies (RT) for correct word trials only, in written modality.

Raw data are presented in Figure 61 page 193.

[93] We thus excluded more participants than in previous experiments. This is probably linked to the fact that Experiment 3 was entirely conducted online, some of the participants being less focused on the tasks than during face-to-face data collection. Note that we performed the same analysis, without the exclusion of those participants. The pattern of results was identical.

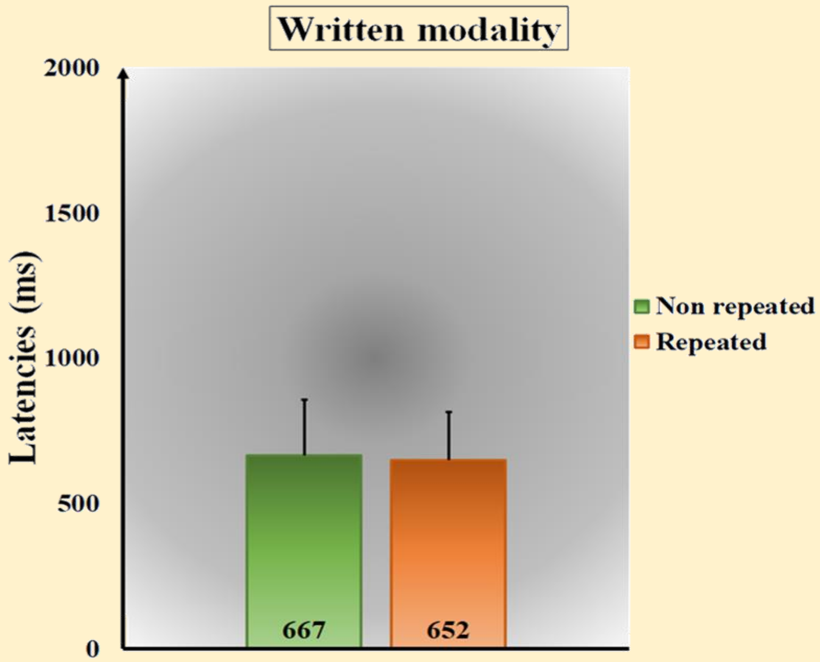

Figure 61. Raw data of latencies – Written modality - French typical-reader university students - Experiment 3.

Final model formula:

The final LMM fitted to the RTs of each participant for each correct word trial included by-participant and by-item random intercepts, and Item-type (Repeated vs. Non-repeated) as fixed effect (best model according to the AIC: F(1,5227.4 = 21.37, $p < .001$). Those fixed effects explained less than 1% of the variance[94] (marginal $R^2 = .002$).

RTs were significantly lower for repeated words than for non-repeated words.

The parameter estimates of the final model fitted to the RTs are reported in Table 44 below.

Table 44. Parameter estimates of the best model fitted to the RTs – Session 2 – Written modality - French typical-reader university students - Experiment 3.

Predictors	b	SE b	t	p
(Intercept)	661.05	11.58	56.62	<.001*
Item-type	-16.29	5.56	-2.93	<.01*

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(RT ~ Item_type + (1 | Participant) + (1 | Item), data = Data_RT_correct_words_Exp3S2Written_Frcntrluniv, REML = TRUE)

[94] This so small marginal R^2 was explained by the fact that the current analysis didn't take into account specific parameters which influence reaction times, notably in written modality, such as length, frequency, …

The parameter estimates of the best model according to the BF[95] are reported in Table 45 below. This model included L2proficiency, in addition with Item-type as fixed effects. This model highlighted a marginally non-significant L2-Proficiency effect, explaining why its suppression resulted in a better fitting.

Table 45. Parameter estimates of the best model fitted to the RTs (and **output from the Bayesian analysis in bold**) – Session 2 – Written modality - French typical-reader university students - Experiment 3.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	665.92	11.53	57.76	<.001*	**665.85**	**11.67**	**[643;689]**
Item-type	-16.32	5.56	-2.94	<.01*	**-16.34**	**5.44**	**[-27;-6]**
L2-Proficiency (DL)	-.12	.06	-1.97	.056	**-.12**	**.06**	**[-.23;.00]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(RT ~ Item_type + Dialang_Level + (1 | Participant) + (1 | Item), data = Data_RT_correct_words_Exp3S2Written_Frcntrluniv, REML = TRUE)

6.3.1.2.Latencies (RT) for correct word trials only, in oral modality.

Raw data are presented in Figure 62 below.

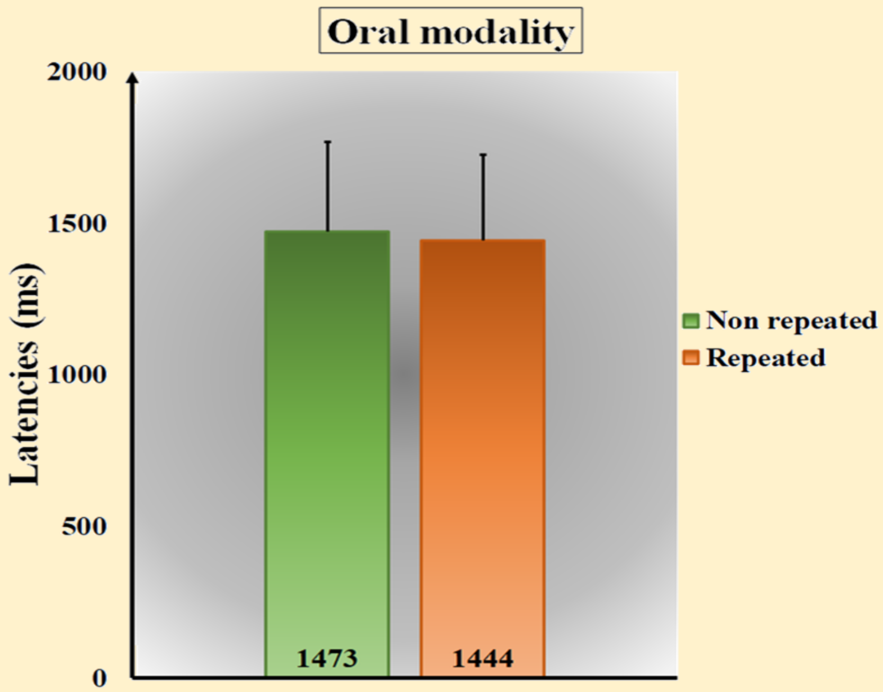

Figure 62. Raw data of latencies – Oral modality - French typical-reader university students - Experiment 3.

[95] Maximum BF = 2,989,135 (bayes_R² = .09, SE = .01, 95% CrI = [.07, .11]).

Final model formula:

The final LMM fitted to the RTs of each participant for each correct word trial included by-participant and by-item random intercepts, and Item-type (Repeated vs. Non-repeated) as fixed effect (best model according to the AIC: F(1,2137.1 = 12.44, $p < .001$). Those fixed effects explained less than 1% of the variance[96] (marginal $R^2 = .003$).

RTs were significantly lower for repeated words than for non-repeated words.

The parameter estimates of the final model fitted to the RTs are reported in Table 46 below.

Table 46. Parameter estimates of the best model fitted to the RTs – Session 2 – Oral modality - French typical-reader university students - Experiment 3.

Predictors	b	SE b	t	p
(Intercept)	1469.93	29.91	45.82	<.001*
Item-type	-32.33	9.17	-3.53	<.001*

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(RT ~ Item_type + (1 | Participant) + (1 | Item), data = Data_RT_correct_words_Exp3S2Oral_Frcntrluniv, REML = TRUE)

The parameter estimates of the best model according to the BF[97] are reported in Table 47 below. This model included L2proficiency, in addition with Item-type as fixed effects. This model highlighted a non-significant L2-Proficiency effect, explaining why its suppression resulted in a better fitting.

Table 47. Parameter estimates of the best model fitted to the RTs (and **output from the Bayesian analysis in bold**) – Session 2 – Oral modality - French typical-reader university students - Experiment 3.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	1471.77	30.47	48.31	<.001*	**1472.99**	**30.40**	**[1412;1533]**
Item-type	-32.33	9.17	-3.53	<.01*	**-32.34**	**9.31**	**[-51;-14]**
L2-Proficiency (DL)	-.06	.12	-.47	.640	**-.06**	**.12**	**[-.30;.19]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(RT ~ Item_type + Dialang_Level + (1 | Participant) + (1 | Item), data = Data_RT_correct_words_Exp3S2Oral_Frcntrluniv, REML = TRUE)

[96] This so small marginal R^2 was explained by the fact that the current analysis didn't take into account specific parameters which influence reaction times, notably in written modality, such as length, frequency, …

[97] Maximum BF = 2.319 (bayes_R^2 = .20, SE = .02, 95% CrI = [.17, .23]).

6.3.2. French typical and dyslexic-reader university students.

6.3.2.1. Latencies (RT) for correct word trials only, in written modality.

Raw data are presented in Figure 63 below.

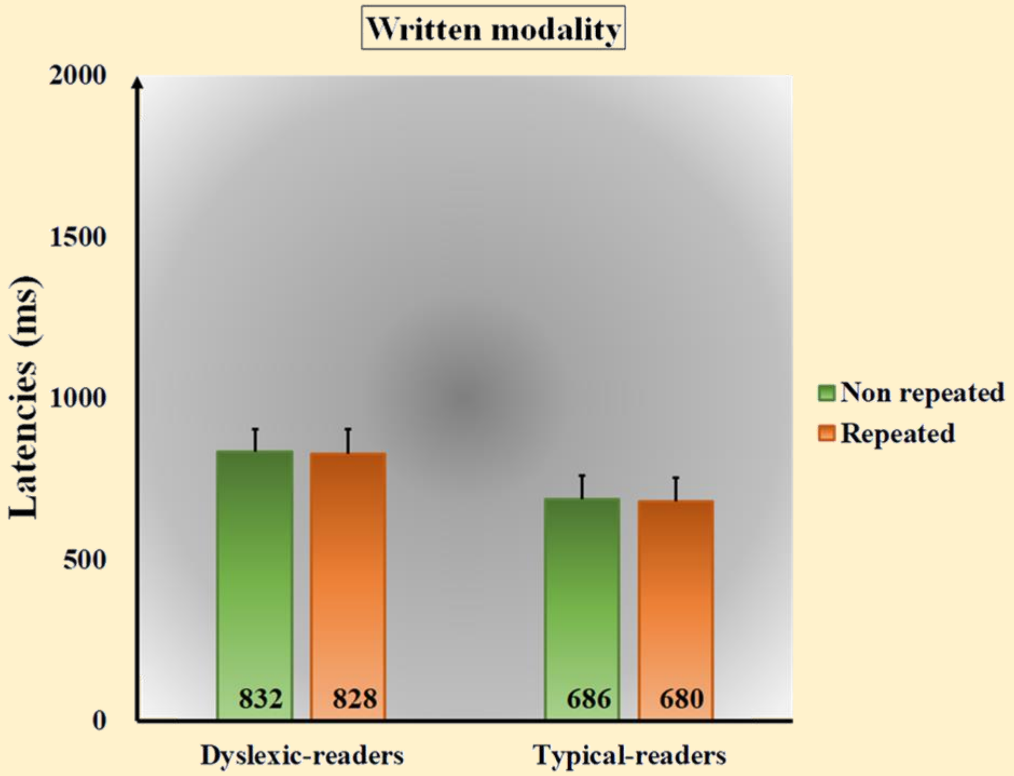

Figure 63. Raw data of latencies – Written modality - French university students, typical and dyslexic-readers - Experiment 3.

Final model formula:

The final LMM fitted to the RTs of each participant for each correct word trial included by-participant and by-item random intercepts, and Group (Typical vs. Dyslexic-readers) as fixed effect (best model according to the AIC: $F(1,13.04= 6.37, p < .05)$. Those fixed effects explained 8% of the variance (marginal $R^2 = .075$).

RTs were significantly lower for typical-readers than for dyslexic-readers.

The parameter estimates of the final model fitted to the RTs are reported in Table 48 page 197.

Table 48. Parameter estimates of the best model fitted to the RTs – Session 2 – Written modality - French university students, typical and dyslexic-readers - Experiment 3.

Predictors	b	SE b	t	p
(Intercept)	760.15	30.28	25.10	<.001*
Group	149.67	59.30	2.52	<.05*

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(RT ~ Group + (1 | Participant) + (1 | Item), data = Data_RT_correct_words_Exp3S2Written_Frcntrlunivdys, REML = TRUE)

The parameter estimates of the best model according to the BF[98] are reported in Table 49 below. This model included L2proficiency and the two-way interaction between L2Proficiency and Group, in addition with Group as fixed effects. This model highlighted a non-significant L2-Proficiency effect, as well as the interaction, explaining why their suppressions resulted in a better fitting. More, group effect was marginally non-significant in the model including the interaction. Main effect of group was significant ($t(982.86) = -9.402$, $p < .001$).

Table 49. Parameter estimates of the best model fitted to the RTs (and **output from the Bayesian analysis in bold**) – Session 2 – Written modality - French university students, typical and dyslexic-readers - Experiment 3.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	741.21	28.45	26.05	<.001*	**741.53**	**29.32**	**[683;800]**
Group	111.76	55.57	2.01	.069	**108.36**	**56.11**	**[-3;218]**
L2Proficiency	-.15	.13	-1.15	.276	**-.16**	**.14**	**[-0;0]**
Group x L2Proficiency	-.37	.27	-1.39	.193	**-.36**	**.28**	**[-1;0]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(RT ~ Group + (1 | Participant) + (1 | Item), data = Data_RT_correct_words_Exp3S2Written_Fruniv_dysctrl, REML = TRUE)

6.3.2.2.Latencies (RT) for correct word trials only, in oral modality.

Raw data are presented in Figure 64 page 198.

[98] Maximum BF = 8.129 * 10^23 (bayes_R^2 = .28, SE = .02, 95% CrI = [.23, .32]).

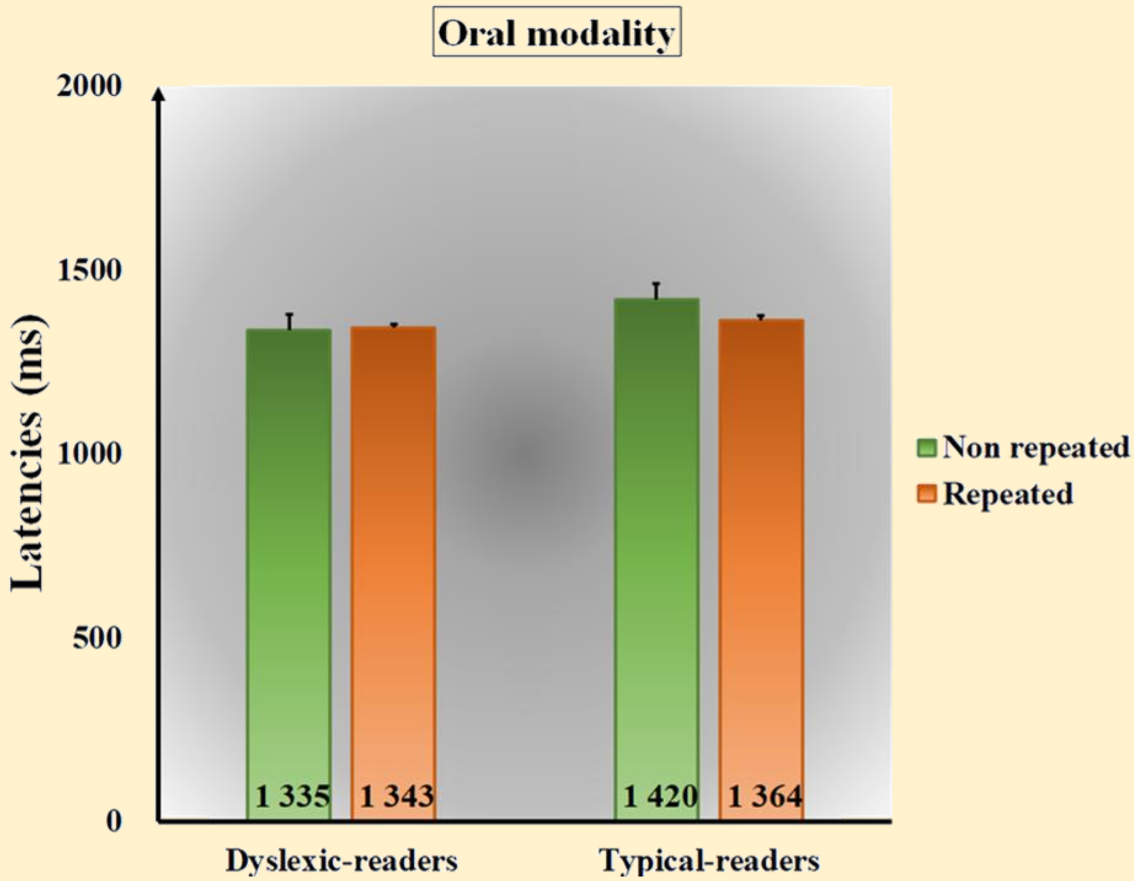

Figure 64. Raw data of latencies – Oral modality - French university students, typical and dyslexic-readers - Experiment 3.

Final model formula:

The final LMM fitted to the RTs of each participant for each correct word trial included by-participant and by-item random intercepts, and Item-type (Repeated vs. Non-repeated) as fixed effect (best model according to the AIC: $F(1,1488.53= 4.90$, $p < .05$). Those fixed effects explained less than 1% of the variance[99] (marginal $R^2 = .002$).

RTs were significantly lower for repeated words than for non-repeated words.

The parameter estimates of the final model fitted to the RTs are reported in Table 50 page 199.

[99] This so small marginal R^2 was explained by the fact that the current analysis didn't take into account specific parameters which influence reaction times, notably in oral modality, such as length, frequency, …

Table 50. Parameter estimates of the best model fitted to the RTs – Session 2 – Oral modality - French university students, typical and dyslexic-readers - Experiment 3.

Predictors	b	SE b	t	p
(Intercept)	1388.96	39.07	35.55	<.001*
Item-type	-26.65	12.05	-2.21	<.05*

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(RT ~ Item_type + (1 | Participant) + (1 | Item), data = Data_RT_correct_words_Exp3S2Oral_Frcntrlunivdys, REML = TRUE)

The parameter estimates of the best model according to the BF[100], including Group (Typical *vs.* Dyslexic-readers) as fixed effects, highlighted a non-significant Group effect. The parameter estimates of the model with Item-type as fixed effect, and its Bayesian version, are reported in Table 51 below. Note that the parameter estimate associated with Item-type was different from 0[101].

Table 51. Parameter estimates of the best model fitted to the RTs (and **output from the Bayesian analysis in bold**) – Session 2 – Oral modality - French university students, typical and dyslexic-readers - Experiment 3.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	1388.96	39.07	35.55	<.001	**1388.29**	**38.93**	**[1310;1463]**
Item-type	-26.65	12.05	-2.21	<.05	**-26.62**	**12.40**	**[-51;-2]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(RT ~ Item_type + (1 | Participant) + (1 | Item), data = Data_RT_correct_words_Exp3S2Oral_Fruniv_dysctrl, REML = TRUE)

[100] Maximum BF = 19.46

[101] bayes_R² = .43, SE = .02, 95% CrI = [.40, .46]. Note that the parameter estimates of the Bayesian version of the model with Group as fixed effect was similar to those of the LMM, with small estimate standard errors and thus relatively small width of CrI, depicting a tiny uncertainty. Moreover, the parameter estimate associated with Group was not different from 0.

6.4. Discussion.

Experiment 3 aimed to evaluate the robustness of the links between L2 orthographic and phonological representations among the population of intermediate proficiency bilinguals, through an analysis of latencies. To do so, Experiment 3 evaluated the extent to which cross-modal repetition of words impacts L2 word recognition latencies. As previously, Table 52 below presents a brief summary of the results of each group. This section will then consist in their simple interpretation, while a theoretical discussion of all experiments of this project will be proposed at the end of the manuscript.

Table 52. Summary of the results - Experiment 3 - all groups.

(Fr = French, U = University students, Typ = Typical-readers, Dys = Dyslexic-readers, G = Group, P = L2 Proficiency, IT = Cross-modal repetition (Item-type: Repeated *vs.* Non-repeated), ✓ = significant effect, ✗ = non-significant effect)

Group	Modality of the test phase	P	G	IT
TypFrUniv	Written	✗	NA	✓
	Oral	✗	NA	✓
DysFrUniv	Written	✗	✓	✗
	Oral	✗	✗	✓

6.4.1. First hypothesis: Cross-modal repetition effect for the test phase in written modality.

Critically, the cross-modal repetition effect (corresponding to the item-type effect, *i.e.*, the difference between repeated and non-repeated words) on Experiment 3 has to be considered as the session effect in Experiment 1. Indeed, concerning latencies for the current experiment, we analysed the RTs of the test phase only, each participant performing this test phase either in oral or in written modality. The item-type effect during this test phase consisted in a difference in latencies between repeated word recognition and non-repeated word recognition. In other words, repeated words were words presented for the second time (as in session 2 of Experiment 1), whereas non-repeated words were presented for the first time (as in session 1 of Experiment 1).

Interestingly, Experiment 3 demonstrated an item-type effect, L2 word recognition being faster for repeated words than for non-repeated words for the test phase in written modality, among typical-reader participants. Thus, with those more frequent[102] words – compared to those of Experiment 1, cross-modal repetition of words leads to their faster recognition. This indicates a benefit from the oral modality over the written one, repeated words for the test phase in written modality being words presented orally in the exposition phase. This finding demonstrated that the first presentation of a spoken English non-cognate word activates a phonological lexical representation, which intermediate proficiency bilinguals use for secondary written word recognition. Therefore, the lexical representation activated when they saw a word they had just heard accelerates its visual recognition.

This finding is congruent with the modality effect observed in Experiment 1. Indeed, this effect suggests an easier activation of L2 orthographic lexical representations, compared to phonological ones. The recognition of an L2 spoken word therefore leads to a pre-activation of its associated orthographic representation, easy to access.

Nevertheless, the effect of item-type was also demonstrated for the test phase in oral modality, L2 word recognition being faster for repeated words than for non-repeated words, among typical-reader participants. Therefore, cross-modal repetition of words leads to their

[102] As a reminder, the higher frequency range of the stimuli in Experiment 3, compared to those of Experiment 1, was a consequence of the aims of those experiments: accuracy analysis for Experiment 1 *vs.* latency analysis for Experiment 3.

faster recognition, whatever the order of presentation of modalities. This finding demonstrated that the first presentation of an English non-cognate word activates a lexical representation, which intermediate proficiency bilinguals use for secondary word recognition, whatever the order of presentation of the modalities. Therefore, the lexical representation activated when they saw a word they had just heard accelerates its visual recognition. Likewise, the lexical representation activated when they heard a word they had just saw accelerates its auditory recognition. The links between orthographic and phonological lexical representations in L2 seem thus robust and bidirectional. This finding is congruent with the Multilink model for bilingual word recognition, which is an interactive model, with bidirectional flows, notably between orthographic and phonological lexical representations in both languages (Dijkstra et al., 2019).

6.4.2. Second hypothesis: No (or at least from a shorter amplitude, compared to Experiment 1) L2 proficiency effect.

Experiment 3 failed to observe an L2 proficiency effect in terms of L2 word recognition latencies. As a reminder, Experiment 1 demonstrated this type of proficiency effect in terms of L2 word recognition accuracy. Therefore, both results seemed incongruent. However, as explained in our hypotheses and method sections, the items chosen for Experiment 3 were from higher frequency ranges than those of Experiment 1, in order to ensure that all words are known by the participants, thus allowing latency analysis. The less frequent words of Experiment 1 were therefore demonstrated to be known in written form more than in oral form, leading to the observed modality effect in L2 word recognition accuracy. In the current experiment, all words assumed to be known, they were also assumed to be less sensitive to L2 proficiency, explaining this expected lack of effect. This is consistent with the Multilink model, which uses resting level activation to take into account L2 proficiency differences, which is related to item subjective frequencies (Dijkstra et al., 2019).

Considering the comparison between dyslexic and typical-readers, we also failed to observe an effect of L2 proficiency. This is probably a consequence of the matching between groups on this parameter, reducing the heterogeneity and thus precluding this effect to be significant, as mentioned in Experiment 1.

6.4.3. Third hypothesis: less sensitivity of dyslexic-readers to cross-modal repetition.

Considering the comparison between dyslexic and typical-readers, we found a group effect on L2 word recognition latencies, for the test phase in written modality only, typical-readers recognizing L2 words faster than dyslexic-readers. This is congruent with the written stimuli processing difficulties of dyslexic-readers (Lyon et al., 2003). This is also consistent with some studies, showing that the skills of dyslexic individuals, and in particular their difficulties in L1, were also observed in L2 (Lindgrén & Laine, 2011a; Palladino et al., 2013; van Setten et al., 2017).

In addition, there was no cross-modal repetition effect (*i.e.*, no item-type effect) for the test phase in written modality when typical and dyslexic-readers were analysed together. Therefore, cross-modal repetition had no impact on L2 word recognition latencies, considering the test phase in written modality among those matched participants. This indicates that dyslexic-reader participants activate their phonological representations of L2 spoken words during the exposition phase in oral modality, but were not able to pre-activate their associated orthographic representations at a level allowing them to overcome their difficulties during secondary written word recognition, which is congruent with their written stimuli processing difficulties (Lindgrén & Laine, 2011a, 2011b; Lyon et al., 2003; Palladino et al., 2013; van Setten et al., 2017). However, we failed to observe an interaction between group and cross-modal repetition (*i.e.,* item-type effect). The lack of cross-modal repetition effect was thus present among both typical and dyslexic-readers. This result is incongruent with that of the complete group of typical-readers. This difference could be linked to a lack of statistical power, due to the limited number of dyslexic individuals in our sample, precluding the interaction to be significant, raw data suggesting this interaction (with a difference in latencies between repeated and non-repeated words of nine milliseconds for typical-readers and four milliseconds for dyslexic-readers).

Concerning the oral modality, we observe the same pattern of results than that of the complete typical-reader group. There was no group effect, which is consistent with the fact that dyslexic individuals present written stimuli processing difficulties, without spoken stimuli processing impairment, in L1 as in L2 (Lindgrén & Laine, 2011a; Lyon et al., 2003). Moreover, there was cross-modal repetition effect, with a faster recognition of repeated words than non-repeated ones. Raw data suggested an interaction between group and item-type effects (with a difference in latencies between repeated and non-repeated words of 53 milliseconds for typical-readers and eight milliseconds for dyslexic-readers[103]), not highlighted by the mixed-effect modelling, probably because of a lack of statistical power, in relation to the limited number of participants in the group of dyslexic-readers.

Interestingly, cross-modal repetition effect was highlighted in both modalities among typical-readers – in favour of repeated words compared to non-repeated words, while this effect appeared only when the test phase was in oral modality among dyslexic-readers – in favour of non-repeated words compared to repeated words. This consists in a major finding. Actually,

[103] Note that this difference for dyslexic-readers was in favour of the non-repeated words.

this result indicates that typical-readers present robust connections between orthographic and phonological lexical representations in L2, with a bi-directionality of those flows, which is consistent with psycholinguistic models of bilingual word recognition, such as the Multilink model (Dijkstra et al., 2019). Conversely, dyslexic-readers present much more imprecise lexical representations in both modalities – given their written stimuli processing difficulties for orthographic ones, and considering their phonological deficit hampering their orthography-to-phonology mappings for phonological ones. Therefore, when the test phase was in written modality, they have taken no advantage of the cross-modal repetition, due to their written stimuli processing difficulties hampering the creation of connection from phonological to orthographic lexical representations. Besides, when the test phase was in oral modality, they derived no benefit from the cross-modal repetition, because their phonological deficit hampers the creation of connections from orthographic to phonological lexical representations. Furthermore, this finding argues in favour of an inhibitory effect of the cross-modal repetition when the test phase was in written modality among dyslexic-readers – and thus of an effect in favour of non-repeated words. This tends to indicate that the phonological deficit of dyslexic-readers results in the activation of incorrect phonological lexical representations, which make more difficult the secondary spoken word recognition.

6.4.4.Limitations.

A major information and limitation of Experiment 3 was the fact that we failed to analyse the data from English-French bilinguals, who were not able to perform the task correctly (with two-third of the sample performing the task at the random level). This could be due to the fact that French stimuli were noticeably less frequent than English stimuli, due to technical issue concerning their selection[104]. Furthermore, it could also be due to a less exposure through medias to French language in English-speaking country than to English language in French-speaking country. Finally, the experimental paradigm allowed a precise analysis of latencies, considering cross-modal repetition of a pre-defined list of L2 stimuli. But it precluded an analysis at the item level. Indeed, if bilinguals are able to benefit from cross-modal repetition at the item level, it would be interesting to help them to take advantage consciously from this pre-activation of lexical representation, in order to improve their L2 skills, notably in oral modality.

6.5. Conclusion.

In conclusion, our results argue in favour of the existence of robust links between orthographic and phonological lexical representations in L2, interacting bidirectionally, among French-English typical-readers from intermediate L2 proficiency. Moreover, our results tended to demonstrate that dyslexic-readers were equally sensitive to cross-modal repetition of L2 words in oral modality than typical-readers were. However, their phonological representations did not allow the pre-activation of their associated orthographic representations at a level allowing them to overcome their difficulties during secondary written word recognition, this result needing to be replicate with a larger sample.

In order to control this modality effect in L1, we proposed the same experiment in L1, to our three groups of participants, constituting Experiment 4 (Chapter 8). We also designed a new experiment to evaluate the ability of bilinguals to benefit from cross-modal repetition of words at the item level, constituting Experiment 5 (Chapter 9).

[104] Indeed, there were not enough items in English considering the same frequency range as in French. We decided to extend this parameter, notably by adding more frequent words, leading to an easier lexical decision task.

Chapter 7. Experiment 4: Impact of cross-modal repetition on L1 word recognition latencies

7.1. Introduction.

Experiment 3 revealed an effect of the repetition across modalities on L2 word recognition latencies, among typical-readers. More, this effect was highlighted among dyslexic-readers, but only in oral modality. Critically, Experiment 2 demonstrated some differences in L1 word recognition between English and French languages. Indeed, French-English bilinguals presented no modality effect in L1, while English-French bilinguals presented a modality effect, in favour of the written one, in L1. We therefore wanted to control whether the cross-modal repetition impact underlined in L2 through Experiment 3 exists also in L1. To do so, we conducted an experiment in L1 using the same paradigm as in Experiment 3, among the same three groups of participants[105]. Experiment 4 aimed thus to evaluate the robustness of the links between L1 orthographic and phonological lexical representations, notably among dyslexic-readers, through an evaluation of the extent to which cross-modal repetition of words impact L1 word recognition latencies.

As Experiment 3, Experiment 4 was implemented exclusively online, *via* the Psytoolkit platform (Stoet, 2010, 2017). It was conducted among the same groups of participants than Experiment 3: a) French university students, all typical-readers; b) French university students, with a comparison of dyslexic and typical-readers; and c) English university students, all typical-readers.

[105] As a reminder, our results in Experiment 3 concerned only the two groups of French participants, but this experiment was proposed to three groups of participants, including a group of English-French bilinguals.

Experiment 4 addressed the question as to the degree to which L1 word recognition is sensitive to the repetition across modalities. We used the same paradigm as in Experiment 3, with two lexical decision tasks, one in each modality, performed one after the other, a counterbalanced order of presentation of modalities across participants, and stimuli lists including words repeated or not across modalities.

According to the dual-route cascaded model of “visual word recognition and reading aloud” (Coltheart et al., 2001), the lexical pathway is based on a direct access to the orthographic form of familiar words, secondarily activating the associated phonological form of each word. More, Experiment 2 demonstrated the absence of modality effect on L1 word recognition accuracy among French typical-readers. Therefore, we expected **typical-readers not** to be **sensitive to the cross-modal repetition in L1**, each representation – orthographic and phonological – being as easy to access as the other. More, **dyslexic-readers** were anticipated **not** to be **sensitive to the cross-modal repetition in L1,** both when the first presentation was in written modality, given their written stimuli processing difficulties, and when the first presentation was in oral modality, considering their phonological deficit. Finally, because **English native-speakers** presented a modality effect in L1 (see Experiment 2), we expected them to be **sensitive to the cross-modal repetition** when the first presentation was **in oral modality**. Indeed, the phonological lexical representation activated during this first spoken word recognition would lead to a pre-activation of the associated orthographic lexical representation, this one being easier to access, facilitating the secondary written word recognition.

7.2. Method.

7.2.1. Participants.

7.2.1.1. French university student groups.

The same participants as in Experiment 3 took part in this experiment. However, because the Psytoolkit platform (Stoet, 2010, 2017) counterbalanced itself the order of presentation of modalities across participants, they did not always perform L1 lexical decision tasks in the same order of presentation of modalities than in Experiment 3. Indeed, the previous 91 participants[106] recruited in Experiment 3 were randomly divided into a writtenfr-TypFrUniv sub-group of 39 French Typical-readers performing both tasks in the oral modality and then in the written modality, and an oralfr-TypFrUniv sub-group of 52 typical-readers performing both tasks in the opposite order of presentation of modalities. Demographic data of these two groups are available in Appendix 30 page 384.

The same dyslexic-reader participants as in Experiment 3 took part in this experiment. However, as for typical-readers, they did not always perform L1 lexical decision tasks in the same order of presentation of modalities than in Experiment 3. Finally, Among the 91 typical-reader participants, we then selected 20 new typical-reader participants matched with the 20 dyslexic-reader participants on age, gender, laterality, socio-economic status, order of presentation of modalities during the French tasks, SRT and CRT. Appendix 31 page 386 presents the pairings between both groups and subgroups. The participants were randomly divided into a writtenfr-DysFrUniv sub-group of 11 dyslexic-readers performing both tasks in the oral modality and then in the written modality (matched with the writtenfr-TypFrUnivMatched sub-group formed by the 11 typical-readers matched), and an oralfr-

[106] As a reminder, ninety-four participants were recruited. Then three participants were excluded due to their longer baseline reaction times (see 6.2.1.1 page 193).

DysFrUniv sub-group of 9 dyslexic-readers performing both tasks in the opposite order of presentation of modalities (matched with the oralfr-TypFrUnivMatched sub-group formed by the 9 typical-readers matched). Demographic data of these sub-groups are available in Appendix 30 page 384.

7.2.1.2.English university student groups.

We recruited 36 participants from the University of Dundee (Scotland, United Kingdom). However, 10 participants needed to be excluded from the analyses *a posteriori*, due to high pseudoword error rates. Therefore, we decided finally not to include this group into the analyses, the remaining group of 26 participants not leading to sufficient sample sizes of both sub-groups.

7.2.2.Questionnaires.

7.2.2.1.French university students.

We administered to the French typical-reader university students the Adult Reading Habits Questionnaire described above (see section 3.2.2 page 63). We administered the same questionnaire to the French dyslexic-reader university students. Appendix 32 page 387 presents the pairings between groups and sub-groups. Dyslexic and typical-readers were similar concerning the exposures to French and English languages. Of course, dyslexic-readers had more difficulties learning to read in primary school and reading currently than typical-readers.

7.2.3.Background tests.

7.2.3.1.French university student groups.

The same background tests as in Experiment 3 were administered to French participants. Appendix 33 page 392 presents the results of those tests, as well as the statistics comparing the different groups and sub-groups of French university students.

7.2.4. Stimuli of French Lexical Decision Tasks.

French words were selected from the Lexique database (New, 2006), using the following criteria: frequency between 100 and 2000[107] per million in written and oral forms, 3-to-12 letter-long, no homophones or homographs (in French and also in English), no plurals or conjugated forms, non-cognate words (mldTE ≥ 4) only.

We then selected from this first list 120 non-cognate words (mldTE ≥ 4). Thirty-one percent were monosyllabic, 63% were disyllabic, others were trisyllabic. All words were 4-to-10 letter-long. We then used the software package Wuggy© (Keuleers & Brysbaert, 2010) to create a list of 120 pseudowords matched with the selected words, using the same pairing parameters as previously.

Finally, we divided the list of 120 pairs of words and pseudowords into three groups (A, B and C) of 40 pairs of words and pseudowords. We checked the pairings between all those stimuli. Appendix 29 page 373 presents the complete pairings and the lists of stimuli.

7.2.5. Procedure.

The procedure was identical to that of Experiment 3.

7.2.6. Statistical analyses.

Data analyses were identical to that of Experiment 3, except that we obviously did not include L2-Proficiency as fixed effect in the analyses.

[107] The aim of Experiment 3 was mainly to analyze latencies of word recognition. Thus, we chose this specific range of frequency in order to be able to analyze latencies properly. We did not use the same frequency range for both English and French item selection, due to technical issue.

7.3. Results.

The aims of Experiment 4 on L1 word recognition were to evaluate the robustness of the links between L1 orthographic and phonological representations, through an analysis of the impact of cross-modal repetition of words on L1 word recognition latencies.

As for previous experiments, the summary of the results would help to follow all the results described below.

7.3.1. French typical-reader university students.

We excluded 5 participants[108] from the analyses, due to their high pseudoword error rates, remaining a writtenfr-TypFrUniv group of 45 participants and an oralfr-TypFrUniv group of 41 participants.

7.3.1.1. Latencies (RT) for correct word trials only, in written modality.

Raw data are presented in Figure 65 below.

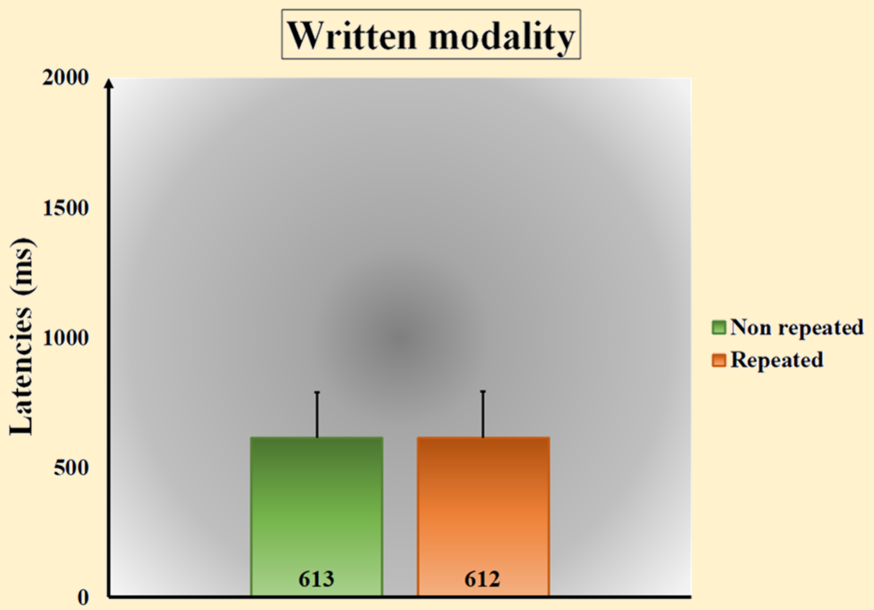

Figure 65. Raw data of latencies – Written modality - French typical-reader university students - Experiment 4.

[108] We also performed the analysis without the exclusion of those participants. The pattern of results was identical.

Final model formula:

The final LMM fitted to the RTs of each participant for each correct word trial included by-participant and by-item random intercepts, and no fixed effect[109] (best model according to the AIC). Those fixed and random effects explained 28% of the variance (conditional $R^2 = .276$).

There was no significant effect.

7.3.1.2.Latencies (RT) for correct word trials only, in oral modality.

Raw data are presented in Figure 66 below.

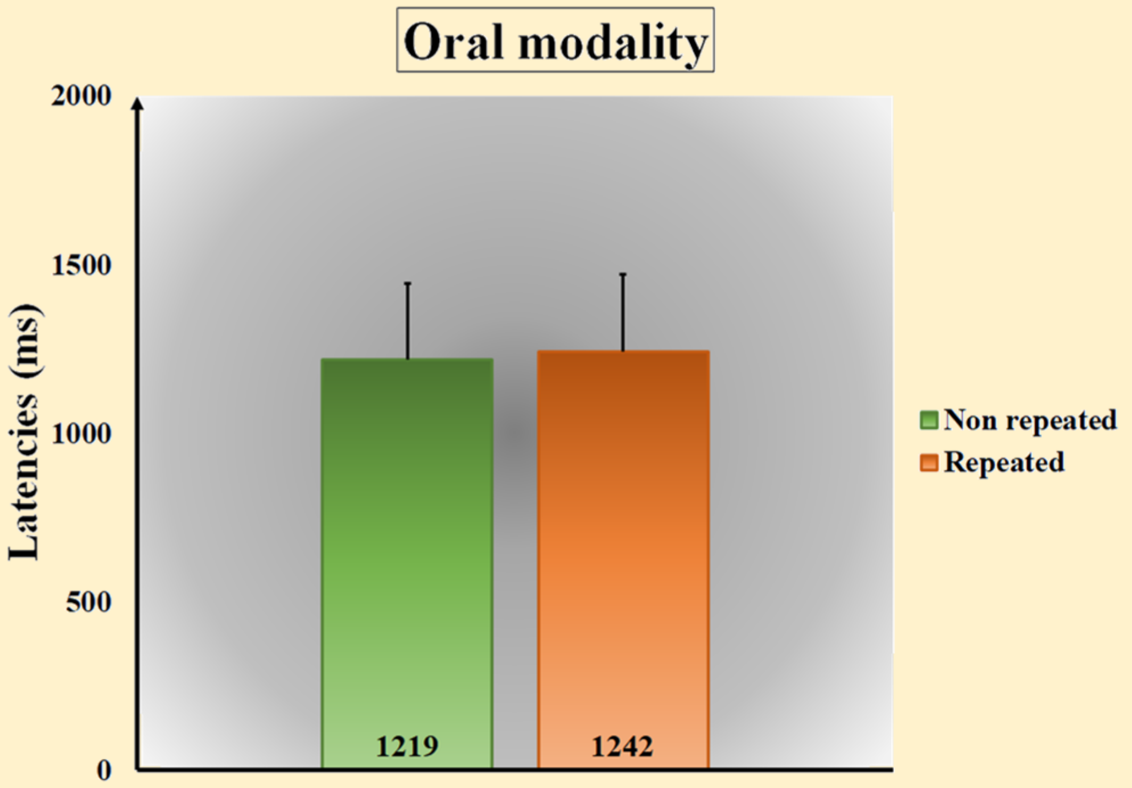

Figure 66. Raw data of latencies – Oral modality - French typical-reader university students - Experiment 4.

Final model formula:

The final LMM fitted to the RTs of each participant for each correct word trial included by-participant and by-item random intercepts, and no fixed effect[110] (best model according to the AIC). Those fixed and random effects explained 37% of the variance (conditional $R^2 = .374$).

[109] Maximum BF = .042, indicating that the most relevant model given the data was the null model.

[110] Maximum BF = 3.086, corresponding to a model formula including Item-type as fixed effect. Item-type effect was however not significant.

There was no significant effect.

7.3.2.French typical and dyslexic-reader university students.

7.3.2.1.Latencies (RT) for correct word trials only, in written modality.

Raw data are presented in Figure 67 below.

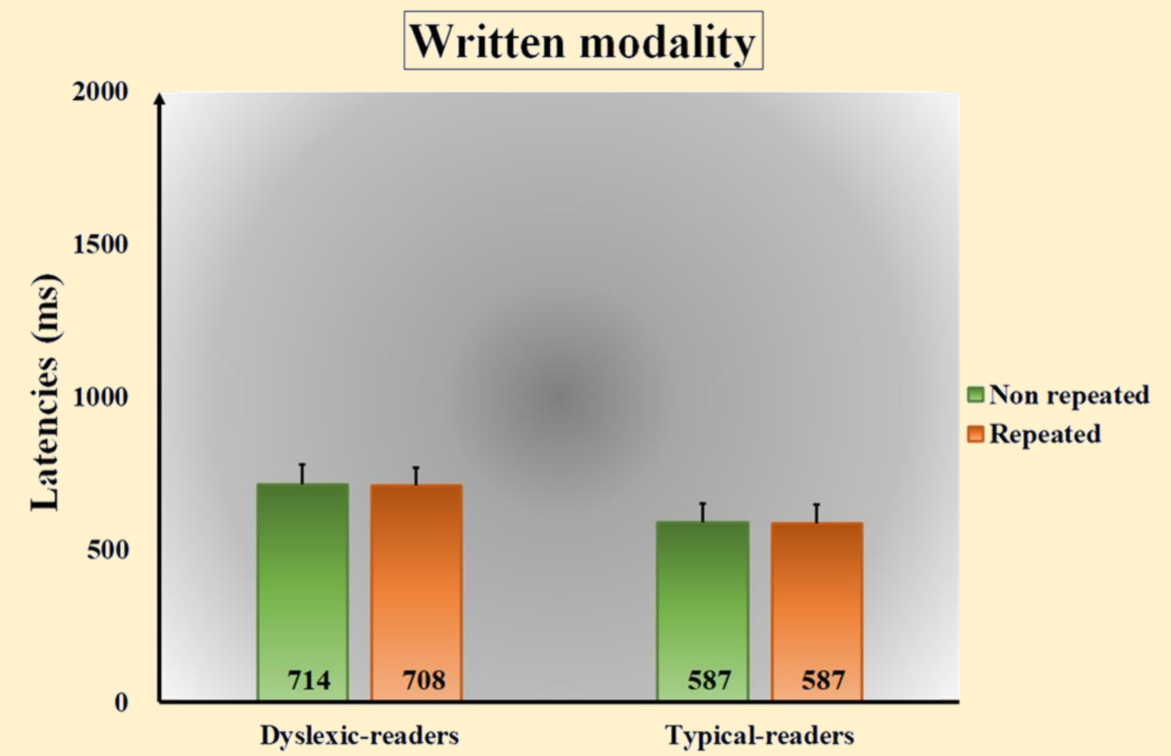

Figure 67. Raw data of latencies – Written modality - French university students, typical and dyslexic-readers - Experiment 4.

Final model formula:

The final LMM fitted to the RTs of each participant for each correct word trial included by-participant and by-item random intercepts, and Group (Typical vs. Dyslexic-readers) as fixed effect (best model according to the AIC: $F(1,18.4= 8.41$, $p < .01$). Those fixed effects explained 6% of the variance (marginal $R^2 = .064$).

RTs were significantly lower for typical-readers than for dyslexic-readers.

The parameter estimates of the final model fitted to the RTs, as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[111], are reported in Table 53 below.

Table 53. Parameter estimates of the final model fitted to the RTs (**and output from the Bayesian analysis in bold**) - French university students, typical and dyslexic-readers - Experiment 4.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	587.11	28.97	20.27	<.001*	**643.22**	**20.64**	**[603;683]**
Group	115.83	39.95	2.90	<.01*	**114.52**	**40.36**	**[33;192]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: lmer(RT ~ Group + (1 | Participant) + (1 | Item), data = Data_RT_correct_words_Exp4S2Written_Fruniv_dysctrl, REML = TRUE)

7.3.2.2.Latencies (RT) for correct word trials only, in oral modality.

Raw data are presented in Figure 68 below.

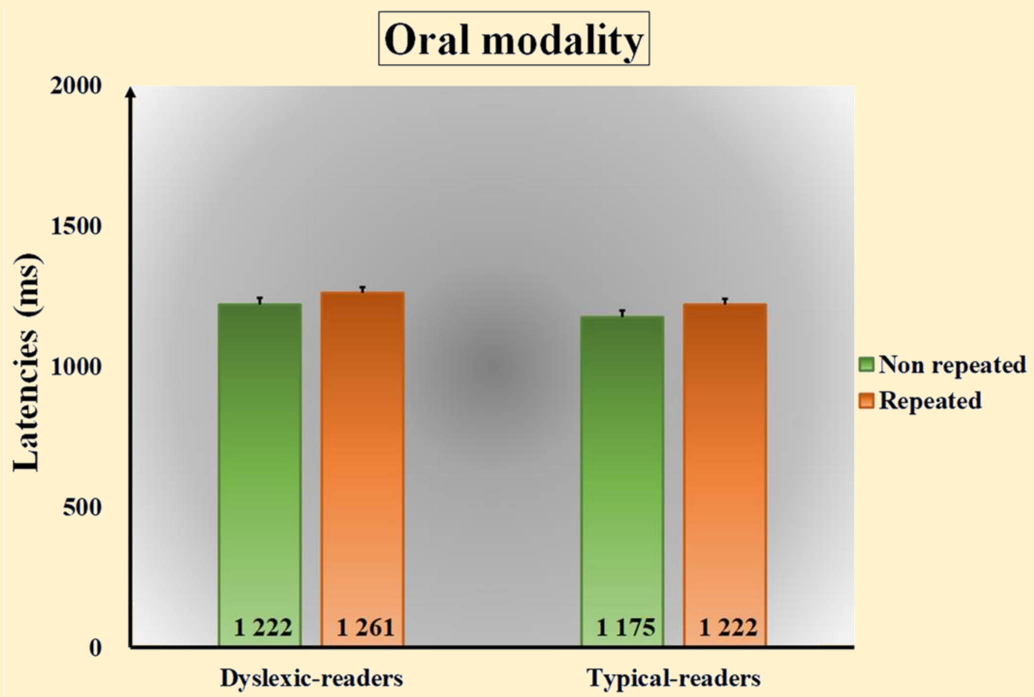

Figure 68. Raw data of latencies – Oral modality - French university students, typical and dyslexic-readers - Experiment 4.

111 Maximum BF = 4.267 * 10^24, corresponding to the same model formula than those of the final model of LMM (bayes_R² = .07, SE = .02, 95% CrI = [.04;.10]).

Final model formula:

The final LMM fitted to the RTs of each participant for each correct word trial included by-participant and by-item random intercepts, and no fixed effect[112] (best model according to the AIC). Those fixed and random effects explained 45% of the variance (conditional R^2 = .447).

There was no significant effect.

7.4. Discussion.

Experiment 4 aimed to address the question as to the degree to which word recognition is sensitive to the repetition across modalities in L1, notably among dyslexic-readers (but also among typical-readers, in order to have a control in L1 for each of our group of participants in Experiment 3). Table 54 below presents a brief summary of the results of each group[113], followed by their simple interpretation. A theoretical discussion for all experiments will be proposed at the end of this manuscript.

Table 54. Summary of the results - Experiment 4 - all groups.

(Fr = French, U = University students, Typ = Typical-readers, Dys = Dyslexic-readers, G = Group, IT = Item-type, ✓ = significant effect, ✗ = non-significant effect)

Group	Modality of the test phase	G	IT
TypFrUniv	Written	NA	✗
	Oral	NA	✗
DysFrUniv	Written	✓	✗
	Oral	✗	✗

[112] Maximum BF = 46.085, corresponding to a model formula including Item-type and Group as fixed effects. Item-type effect was however marginally non-significant, and Group effect was not significant.

[113] As a reminder, the group of English students was excluded from the analyses, because of a too small remaining sample size.

7.4.1. First hypothesis: no impact of cross-modal repetition in L1 among typical-readers.

As expected, Experiment 4 failed to highlight an Item-type effect on L1 word recognition latencies, non-repeated words being recognized as faster as repeated words among typical-readers. This is congruent with the findings of Experiment 2, demonstrating the absence of modality effect on L1 word recognition accuracy among French typical-readers. Thus, at the level of the list, the access to L1 words does not depend on previous presentations of those words in the other modality, both representations (orthographic and phonological) being as easy to access. Moreover, the items used in Experiment 4 being frequent, the cross-modal repetition did not lead to a decrease of the activation threshold of the lexical representation in the other modality, the baseline of activation being already high. Orthographic representations of French L1 words seem connected to phonological ones, the robustness of the links depending on French exposure and thus lexical frequencies. Indeed, frequent words, having been encountered so many times by university students, were recognized quickly – and thus could not benefit from the cross-modal repetition of words.

7.4.2. Second hypothesis: no impact of cross-modal repetition in L1 among dyslexic-readers.

Considering the comparison between typical and dyslexic-readers, Experiment 4 highlighted a group effect in written modality, typical-readers recognizing L1 words faster than dyslexic-readers, while L1 words were recognized as fast in oral modality by both groups. This classical effect is consistent with dyslexic-reader difficulties in written stimuli processing (Lyon et al., 2003).

More and as expected, we found no item-type effect, nor in written modality or in oral one. This is in line with the fact that phonological lexical representations are linked with imprecise orthographic representations among dyslexic-readers, in relation to their written stimuli processing difficulties (Veivo, 2017). In addition, their orthographic representations being imprecise, they are not able to lead to a benefit for secondary spoken word recognition, through a pre-activation of their associated phonological representations. However, there was no significant effect among typical-readers, making it difficult to conclude from the absence of effect among dyslexic-readers.

7.4.3. Limitations.

There are some limitations to this study, such as the fact that we failed to analyse the data from English-French bilinguals, who were not able to perform the task correctly (with two-third of the sample performing the task at the random level), even in L1. This is crucial and was probably linked with the fact that this experiment was conducted online. Indeed, in France, participants were paid for completing the tasks, which provided an external motivation for conducting the experiment. This is a significant bias associated with online experimentation. Finally, the experimental design used prevents us to analyse the links between orthographic and phonological lexical representations at the level of items, the level of lists being the unique level available to analyse. Indeed, the experimental paradigm allowed a precise analysis of latencies, considering cross-modal repetition of a pre-defined list of L1 stimuli. But it precluded an analysis at the item level. Indeed, if participants are able to benefit from cross-modal repetition at the item level, notably considering dyslexic-readers, it would be interesting to help them to take advantage consciously from the pre-activation of orthographic lexical representation, in order to improve their written word recognition.

7.5. Conclusion.

In conclusion, our results argue in favour of the absence of cross-modal repetition impact on L1 word recognition among French university students. Moreover, the unique significant effect underlined was that of group, during the comparison of typical and dyslexic-readers, as expected due to the latter written processing difficulties. Finally, the difficulties to analyse English participant data was of major interest, concerning the parameters on which efficacy of online experimentation depends.

The experimental designs used previously not allowing an analysis of the robustness of the links between orthographic and phonological representations of English words at the item level, we have implemented a third experimental design, constituting Experiment 5 (Chapter 9).

Chapter 8. Experiment 5: Impact of cross-modal repetition priming on L2 word recognition

8.1. Introduction.

Experiment 1 highlighted a modality effect on L2 word recognition accuracy, in favour of the written modality, among both French-English and English-French bilinguals. This modality effect was demonstrated both among French university students and middle-schoolers. Conversely, Experiment 2 demonstrated that this type of effect exists on L1 word recognition accuracy among English-French bilinguals only. Nevertheless, because the paradigm used in Experiments 1 and 2 was designed to analyse accuracy, it precluded an analysis of latencies. Therefore, Experiment 1 demonstrated that L2 orthographic lexical representations are easier to access than phonological ones, without any session effect – *i.e.*, without any benefit from one modality over the other, in terms of accuracy. Nevertheless, we were not able to determine the extent to which each L2 lexical representation (orthographic or phonological) could pre-activate the associated one in the other modality, allowing a faster recognition of the corresponding word in the other modality.

Experiments 3 and 4 were designed to overcome this lack. They showed that this pre-activation exists in L2, both from written and oral modalities over the other, among typical-readers. More, cross-modal repetition had no impact on L1 word recognition latencies. However, those experiments analysed the pre-activation of associated lexical representations, *via* the impact of cross-modal repetition at the level of the list, a group of 40 words being repeated or not across modalities. No information was available concerning the impact of cross-modal repetition at the item level, which would be more precise and could help to better understand the links proposed between each lexical representation of a single word in bilingual models of word recognition, such as Multilink (Dijkstra et al., 2019). In addition, the effect sizes associated with this effect in Experiment 3 were very small (about 1% of variance).

Furthermore, Experiments 3 and 4 being implemented entirely online, they demonstrated the importance of face-to-face experimentations, notably through the results of the group of English-French bilinguals. Indeed, even in L1 with frequent words, a huge part of those participants performed word recognition at the random level, demonstrating their lack of investment in the task, and explaining our need to exclude so many participants that it precluded any statistical analysis of data.

Therefore, Experiment 5 was designed in order to precise, at the item level, the findings of previous experiments. It aimed to determine if French-English bilingual individuals could benefit from the pre-activation of the orthographic lexical representation of an English word when recognizing the same word in oral modality, at the item level. We decided to conduct this study with face-to-face experimentations, in order to avoid the lack of investment of our participants. More, we analysed the cross-modal repetition impact from the written modality over the oral one only, because of: a) technical issue (the paradigm used requiring the masking of primes, which is more complex for spoken stimuli); and b) our aim to determine if late bilinguals could benefit from their L2 orthographic lexical knowledge during L2 spoken word recognition, in order to improve their oral skills (being lower than written ones, *cf.* modality effect highlighted in previous experiments). Finally, Experiment 1 highlighting a double-sided cognate effect, facilitating in written modality, but hampering at least partially in oral modality, we decided to further explore this finding by including both cognate and non-cognate words into the list of stimuli of the current experiment. Furthermore, the amount of orthographic overlap having major impact on word recognition, Experiment 5 involved both identical and non-identical cognate words.

We thus designed a cross-modal repetition priming paradigm, with written primes and spoken targets, in English. Indeed, the literature was full of studies based on this paradigm, in L1 and cross-languages experiments (Bijeljac-babic et al., 1997; Ferrand & Grainger, 1994; Grainger et al., 2003; Peressotti & Grainger, 1999; Van Heuven et al., 2001), showing the existence of orthographic and phonological priming effects among expert-readers. They also demonstrated that prime-duration, called Stimuli Onset Asynchrony (SOA), was of major importance. Short SOA (less than 50 milliseconds) were associated with orthographic priming, whereas long SOA (more than 50 milliseconds) were associated with phonological priming (see notably: Ferrand & Grainger, 1994; Grainger et al., 2003). Actually, in 2003, Grainger and collaborators designed four experiments based on the masked priming paradigm within and between-modalities.

In 2013, Veivo and Järvikivi based their experimental design on this masked priming paradigm (Grainger et al.,2003) and proposed a cross-modal masked priming paradigm in French as an L2, to Finnish students, with written primes and oral targets. They showed that L2 Proficiency modulates the amplitude of priming effects, with an SOA of 67 milliseconds. Therefore, Experiment 5 consisting in L2 spoken word recognition and our target population being composed of French-English university students, with intermediate L2 proficiency, we decided to test two possible SOA: 50 and 67 milliseconds, pursuing different objectives. Indeed, prime-duration is a major parameter, which leads participants to access to different information. With an SOA at 50 milliseconds, we are pretty sure to be in a masked condition, in which participants have time to access to orthographic information, but not to phonological one (Ferrand & Grainger, 1994; Grainger et al., 2003). A longer SOA (67 milliseconds) allows an access to phonological information (see notably pseudo-homophone priming effect with long SOA: Grainger et al., 2003; Veivo & Järvikivi, 2013). That is why we decided to counterbalanced across participants the two SOA at 50 and 67 milliseconds, in order to determine the extent to which phonological processing could reduce the amplitude of the priming effect, demonstrating that English language incongruence leads to a particular difficulty to apply the correct OPM, and thus to build precise orthographic and phonological lexical representations in L2, associated with each other.

L2 proficiency modulating priming effects (Veivo & Järvikivi, 2013), we adopted a cross-sectional perspective, recruiting both university students and middle-schoolers in France. We proposed to middle-schoolers the same task as university students, but with 67 milliseconds of SOA only, because of their anticipated lower L2 proficiency. Our aim was to determine if the impact of cross-modal repetition exists early during L2 learning, or if it appears progressively when proficiency increases.

Finally, because some studies analysing orthographic priming among dyslexic-readers displayed opposed results (*i.e.,* with no priming effect in some studies: Layes et al., 2019; and orthographic priming effect in others: Welcome & Trammel, 2017), and due to the difficulty to recruit dyslexic participants for long face-to-face experimentations, Experiment 5 was proposed only to participants with no written processing difficulties (*i.e.,* without developmental dyslexia notably).

Therefore, Experiment 5 was proposed to five groups of participants: a) two groups of French typical-reader university students: 50FU and 67FU, with SOA respectively at 50 and 67 milliseconds; b) a group of French typical-reader middle-school students, with SOA at 67 milliseconds; and c) two groups of English monolinguals, all typical-reader university students, constituting a control group in English as an L1, 50EU and 67EU, with SOA respectively at 50 and 67 milliseconds.

We expected to observe a **priming effect among French-English university students**. In addition, we anticipated **amplitude differences** in priming effects between the two groups of French-English university students, with **larger amplitude for the 50FU group than the 67FU group**, demonstrating the impact of phonological processing among the 67FU group, which would interfere with orthographic lexical representation activation, and would thus reduce the priming effect. We also expected to observe a **priming effect among French-English middle-schoolers**, from **lower amplitude** than that of the 67FU group, in relation with their lower L2 proficiency. Due to the double-sided cognate effect demonstrated in Experiment 1, we anticipated that **cognate words** would **interfere with this priming effect**. Indeed, cognate words would elicit longer latencies in this experiment with spoken lexical decision task. More, repeated cognate words were expected to reduce the amplitude of the priming effect, due to their ambiguous connections between orthographic and phonological representations. Among cognate words, we expected **identical** ones to have **higher interference** (*i.e.*, much more reduced amplitude of the priming effect) than non-identical ones.

We anticipated latencies to be **dependent on L2 Proficiency** for both French-English university students and middle-schoolers: the higher the proficiency, the faster the latencies. In addition, an **interaction between L2 Proficiency and the SOA** was expected, the phonological information assumed to be more disadvantageous for the lowest proficiency participants, in relation to the interaction between L2 Proficiency and Modality effects highlighted in previous experiments. Thus, for the shortest SOA, all participants, whatever their L2 Proficiency, were assumed not to be able to process phonologically L2 words, having not enough time. However, for the longest SOA, the highest proficiency participants would have enough time to process L2 words phonologically, while this processing would be more difficult for the lowest proficiency participants. Thus, the highest proficiency participants would be able to access to the phonological lexical representations of words, while the lowest proficiency participants would not. Furthermore, we expected an **interaction between L2 Proficiency and the priming effect**: the lowest the proficiency, the shortest the amplitude of the priming effect. This interaction would reflect the fact that the links between orthographic and phonological lexical representations in L2 are gradually developed when L2 Proficiency increases.

Finally, English students performing the task in L1, they were anticipated to present a **huge benefit of this cross-modal repetition**, given the high frequency range of the items used, with **larger amplitude** of this effect in the 50EU group than in the 67EU group, due to the phonological processing of primes.

8.2. Method.

8.2.1. Participants.

8.2.1.1. French typical-reader university student group.

French typical-reader university students were recruited from several universities of the Hauts-de-France Region. All of them were native-speakers of French, having learned English as an L2 in a school context in France. They had no hearing problems and normal or corrected-to-normal vision. We thus recruited a group of 88 participants, from which none of them reported any kind of learning impairment. They constituted the group of French typical-reader university students, randomly divided into a 50FU sub-group of 44 typical-readers performing the task with a prime duration at 50 milliseconds, and a 67FU sub-group of 44 typical-readers performing the task with a prime duration at 67 milliseconds. Demographic data of these sub-groups (and pairings between them) are available in Appendix 34 page 394.

8.2.1.2. French typical-reader middle-school student group.

French typical-reader middle-school students were recruited from several middle-schools of the Hauts-de-France Region. All of them were native-speakers of French, having learned English as an L2 in a school context in France. They had no hearing problems and normal or corrected-to-normal vision. We thus recruited a group of 51 participants, from which none of them reported any kind of learning impairment. They constituted the group of French typical-reader middle-school students, all of them performing the task with a prime duration at 67 milliseconds (67FM group). However, 30 participants needed to be excluded from the analyses *a posteriori*, due to their high pseudoword error rates. Therefore, we decided finally not to include this group into the analyses.

8.2.1.3. English university student groups.

Finally, we recruited a group of 60 participants from the University of Dundee (Scotland, United Kingdom). All of them were native-speakers of English. They had no hearing problems and normal or corrected-to-normal vision. None of them reported any kind of learning impairment. They constituted a control group of English monolinguals, randomly divided into a 50EU sub-group of 30 typical-readers performing the task with a prime duration at 50 milliseconds, and a 67EU sub-group of 30 typical-readers performing the task with a prime duration at 67 milliseconds. Demographic data of these sub-groups (and pairings between them) are available in Appendix 35 page 395.

8.2.2. Questionnaires.

8.2.2.1. French university student groups.

We administered to the French typical-reader university students the Adult Reading Habits Questionnaire described above (see section 3.2.2 page 63). The complete analysis of answers is available in Appendix 36 page 396.

8.2.2.2. English university student groups.

An English translation of the Adult Reading Habits Questionnaire was administered to the English typical-reader university students. The complete analysis of answers is available in Appendix 37 page 398.

8.2.3. Background tests.

The participants performed the same background tests as in Experiment 1. In addition, university students performed the Deary-Liewald Reaction Time task, as in Experiment 3, in order to determine their baseline reaction time. The complete analysis of the results of each group are available in Appendix 38 and Appendix 39 pages 400 and 401.

8.2.4. Stimuli selection and recordings for spoken LDT.

The auditory stimuli were recorded by two native speakers (native English-speaking man and woman) using the software package Audacity© (*Audacity - Copyright © 1999-2018.*). Each stimulus had its own associated file. The audio files were 44,100 Hz stereo wav files and lasted about 1,000 ms. Male and female voices were randomly counterbalanced across participants. The same stimuli were used for each of the three groups of participants.

Words were selected from the draft database of the APPREL2 ANR project mentioned previously, using the following criteria: frequency between 50 and 120 per million in written form, frequency between 50 and 120 per million in oral form according to the SUBTLEX-UK© database[114] (Van Heuven et al., 2014), 4-to-8 letter-long, no homophones or homographs (in English and also in French), no plurals or conjugated forms, no item used in previous experiments. From this first list, we then selected words as primes and targets for the cross-modal repetition priming task.

We thus selected 120 words: 60 non-cognate words (mldTE ≥ 4) and 60 cognate words (30 non-identical cognate words – 0 < mldTE < 3 – and 30 identical cognate words – mldTE = 0). Thirty percent were monosyllabic, others were disyllabic. We then used the software

[114] It existed no database providing lexical frequencies in oral form for L2 learners. That is why we decided to use this database, commonly used for experiments among monolinguals.

package Wuggy© (Keuleers & Brysbaert, 2010) to create a list of 120 pseudowords matched with the selected words. For the pairings, the same criteria as previously were taken into account. Appendix 40 page 402 presents the pairings between words and pseudowords.

Among those 120 pairs of words and pseudowords, we then selected 80 pairs which constituted the target list. Each item of the target list was associated with two possible primes: a repeated prime (*i.e.*, the same item as the target) and a non-repeated prime (*i.e.*, a different item, corresponding at one of the 40 pairs non included into the target list). Finally, we counterbalanced the prime-type across participants, by constituting two technical lists – namely list A and list B. In each technical list, the targets were identical, while there were 40 pairs with repeated primes and 40 pairs with non-repeated primes. For each target, if the repeated prime was used in list A, the non-repeated prime was used in list B, and *vice-versa*. Appendix 40 page 402 presents the complete pairings and lists of stimuli.

8.2.5. Procedure.

All participants were tested in a quiet room at their university, on the same testing apparatus. They performed cross-modal priming task in English, with a randomly counterbalanced technical list. There was a short break within the task (5 min). The task was preceded by practice trials with verbal feedback from the examiner.

The experiment was run using the DMASTR software (DMDX© version 5.1.5.3) developed at Monash University and at the University of Arizona by K.I. Forster and J.C. Forster (Forster & Forster, 2003). The stimuli (pairs of primes and targets) were shuffled for each participant by the DMASTR software itself.

Written primes were presented on the same apparatus as those of Experiment 1. Stimuli were presented in uppercase in Courier New (11-point font size). They appeared as black characters on a white background. Spoken targets were presented using exactly the same apparatus as in Experiment 1. The sequence of each trial was the following: (1) a fixation cross (+) appeared in the centre of the screen for 1,000 milliseconds; (2) a pre-mask constituted by a series of consonants in uppercase (TGHDFSMN) appeared in the centre of the screen for 500 milliseconds; (3) the written prime (word or pseudoword) was presented in the centre of the screen for 50 or 67 milliseconds, depending on the counterbalanced prime duration of each participant; (4) a series of hashes (#########) appeared in the centre of the screen, while the spoken target (corresponding to the prime in the technical list assigned to the participant) was played binaurally, until the participant's answer or for 4,000 milliseconds maximum if no response was made. The inter-stimuli interval was 200 milliseconds long.

Participants responded on an XBOX© 360 Controller, which does not have time delays with keyboards (Shimizu, 2002). We measured accuracy (percentage of correct responses) for word trials, and reaction time (in milliseconds) for correct word trials.

8.2.6. Statistical analyses.

Data analyses were conducted as mentioned in section 3.4 page 67. We checked in each group if mean accuracy was enough to allow reaction time analysis. Then, we analysed reaction times with mixed-effect modelling and Bayesian statistics, including SOA (67 *vs.* 50 milliseconds), Prime-type (Repeated *vs.* Non repeated), L2-Proficiency (Dialang Level out of 1,000), Cognateness (Cognate *vs.* Non-cognate words), and their interactions as fixed factors, each group being analysed separately. Finally, we compared the different groups with the same SOA, in order to compare this priming between L1 and L2.

8.3. Results.

8.3.1. French typical-reader university students.

Concerning French-English university students, we excluded 30 participants[115] from the analyses, due to their high pseudoword error rates, remaining a 67FU sub-group of 32 participants and a 50FU sub-group of 26 participants.

8.3.1.1. Raw data of accuracy.

Mean accuracy of word recognition according to SOA was presented in Table 55 below.

Table 55. Mean (SD) accuracy of word recognition for each sub-group – French typical-reader university students - Experiment 5.

	Mean accuracy (SD)
50FU	78% (41)
67FU	83% (38)

8.3.1.2. Raw data of latencies.

Mean raw reaction times according to prime duration, Prime-type, and Cognateness, for correct word trials, are available in Figure 69 page 231.

[115] Because the priming could have an inhibitory effect, we also performed the same analysis, without the exclusion of those participants. The pattern of results was identical.

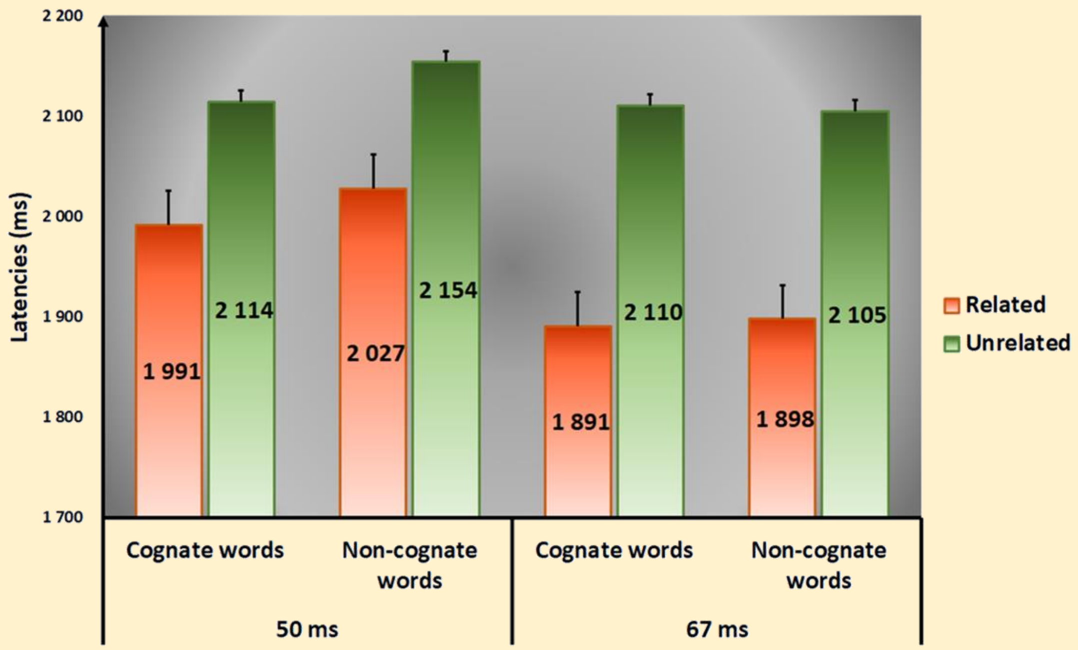

Figure 69. Raw data of latencies – French typical-reader university students - Experiment 5.

8.3.1.3. Analysis of latencies, all words[116].

Final model formula:

The final LMM fitted to the RTs of each participant for each correct word trial included by-participant random intercepts and random slopes considering the Prime-type, by-target random intercepts and random slopes considering SOA, and SOA, Prime-type (Related vs. Unrelated), L2-Proficiency (Dialang Level out of 1,000) and the two-way interaction between SOA and Prime-type as fixed effects (best model according to the AIC: $F(1,57.5 = 6.20, p < .05)$. Those fixed effects explained 13% of the variance (marginal $R^2 = .129$).

RTs were significantly lower for the longest SOA (67 milliseconds – 1993 ms, SD = 297) than the shortest SOA (50 milliseconds – 2068 ms, SD = 279), and for related primes (1944 ms, SD = 288) than for unrelated primes (2119 ms, SD = 267), with a priming effect of 175 milliseconds. In addition, L2-Proficiency effect was also significant, an increase of DL score of 100 out of 1,000 resulting in a decrease of 22 milliseconds of the latencies, as displayed

[116] The same analysis was performed on cognate words only, including Cognate-type (Identical cognate words *vs.* Non-identical cognate words) as fixed effect, instead of Cognateness. We obtained exactly the same pattern of results concerning SOA, Prime_type and L2-Proficiency. Note that there was no cognate-type effect.

by Figure 70 below. Interestingly, the two-way interaction between SOA and Prime-type was significant, latencies being lower for related primes than unrelated primes, with larger amplitude of this priming effect with an SOA at 67 ms (amplitude of 208 ms), compared to an SOA at 50 ms (amplitude of 126 ms). Note that there was no cognate effect in the model including the other factors, while raw data suggested an interaction between Cognateness and SOA. Post-hoc tests demonstrated that a cognate effect, with cognate words faster recognized than non-cognate ones) existed with the shortest SOA (50 milliseconds, $t(1578.7) = -2.470$, $p < .01$), but not for the longest SOA (67 milliseconds, $t(2070.6) = .184$, $p = .573$).

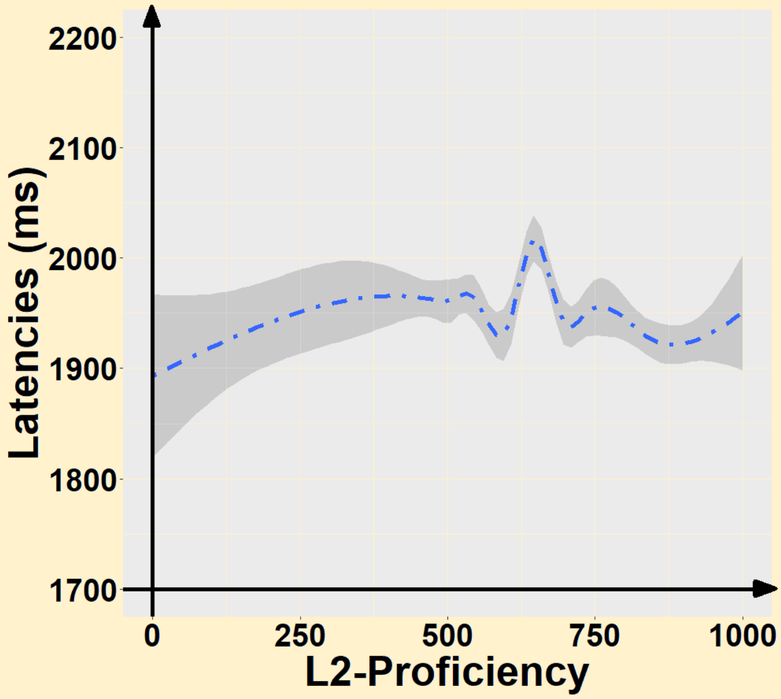

Figure 70. Latencies as a function of Dialang Score (out of 1,000): dotdashed line is the regression line, the area around id the 99% confidence interval - French typical-reader university students - Experiment 5.

Note that the Figure 70 above seemed somehow odd for the participants with intermediate proficiency, probably in relation to some noise, having more impact on word recognition among those participants. Moreover, the observation of the data suggested an interaction between L2 Proficiency and SOA, while this interaction was not included into the model (probably due to a lack of statistical power given the number of other factors included).

We therefore conducted post-hoc tests which highlighted this interaction: a proficiency effect existing for the longest SOA only, as displayed by Figure 71 below.

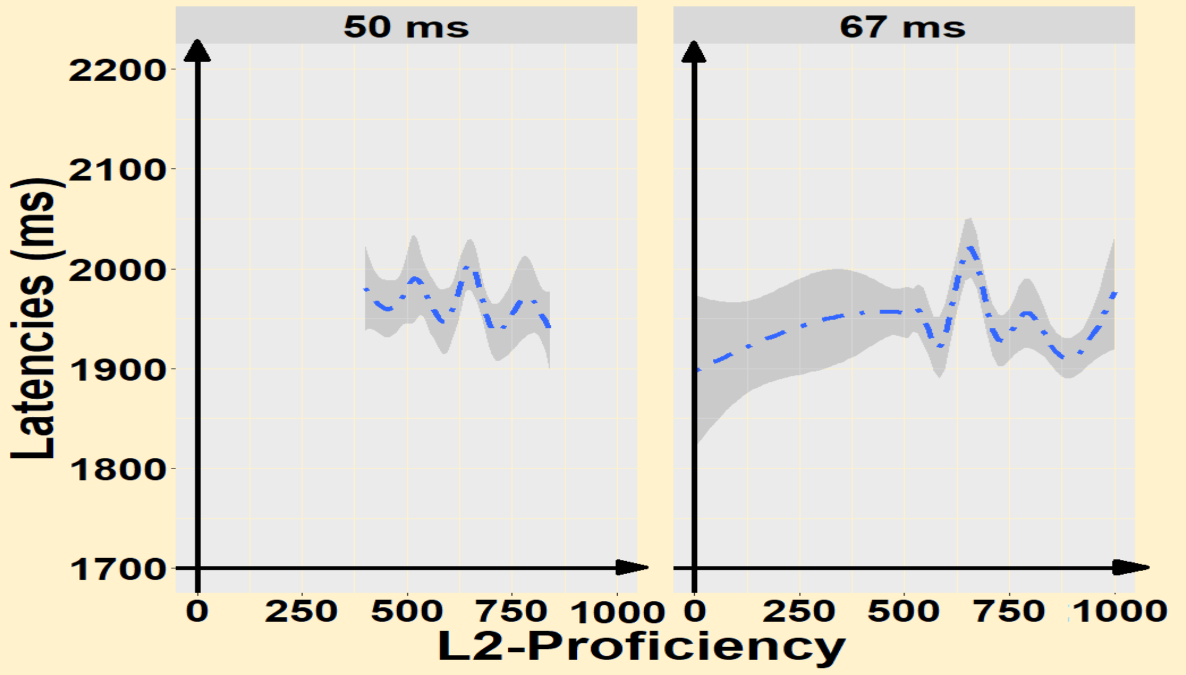

Figure 71. Latencies as a function of Dialang Score (out of 1,000) and SOA: dotdashed line is the regression line, the area around id the 99% confidence interval - French typical-reader university students - Experiment 5.

The parameter estimates of the final model fitted to the d', as well as the outputs from the Bayesian analyses corresponding to the best model according to the BF[117], are reported in Table 56 below.

Table 56. Parameter estimates of the final model fitted to the RTs (**and output from the Bayesian analysis in bold**) –French typical-reader university students - Experiment 5.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	2066	20	104.25	<.001*	**2052**	**19**	**[2006;2081]**
SOA	68	32	-2.16	<.05*	**89**	**10**	**[71;108]**
Prime-type	174	18	9.82	<.001*	**117**	**10**	**[98;136]**
L2 Proficiency	-.22	.09	-2.49	<.05*	**-.28**	**.11**	**[-.50;-.07]**
SOA x Prime_type	98	35	2.77	<.01*	**100**	**10**	**[80;119]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(RT ~ SOA + Prime_type + Dialang_Level + SOA:Prime_type + (1+Prime_type | Participant) + (1 + SOA |Target), data = Data_RT_words_Exp5_Frcntrluniv, family = gaussian)

117 Maximum BF = 2.067 * 10^102, corresponding to the same model formula than those of the final model of LMM (bayes_R² = .41, SE = .01, 95% CrI = [.39, .43]).

8.3.2. English monolinguals.

Concerning English-French university students, we excluded one participant from the 50EU sub-group due to technical issue. Then, we excluded 6 participants[118] from the analyses, due to their high pseudoword error rates, remaining a 67EU sub-group of 26 participants and a 50EU sub-group of 27 participants.

8.3.2.1. Raw data of accuracy.

Mean accuracy of word recognition according to SOA was presented in Table 57 below.

Table 57. Mean (SD) accuracy of word recognition for each sub-group – English typical-reader university students - Experiment 5.

	Mean accuracy (SD)
50EU	96% (21)
67EU	96% (20)

8.3.2.2. Raw data of latencies.

Mean raw reaction times according to prime duration and Prime-type, for correct word trials, are available in Figure 72 page 235.

[118] We also performed the same analysis, without the exclusion of those participants. The pattern of results was identical.

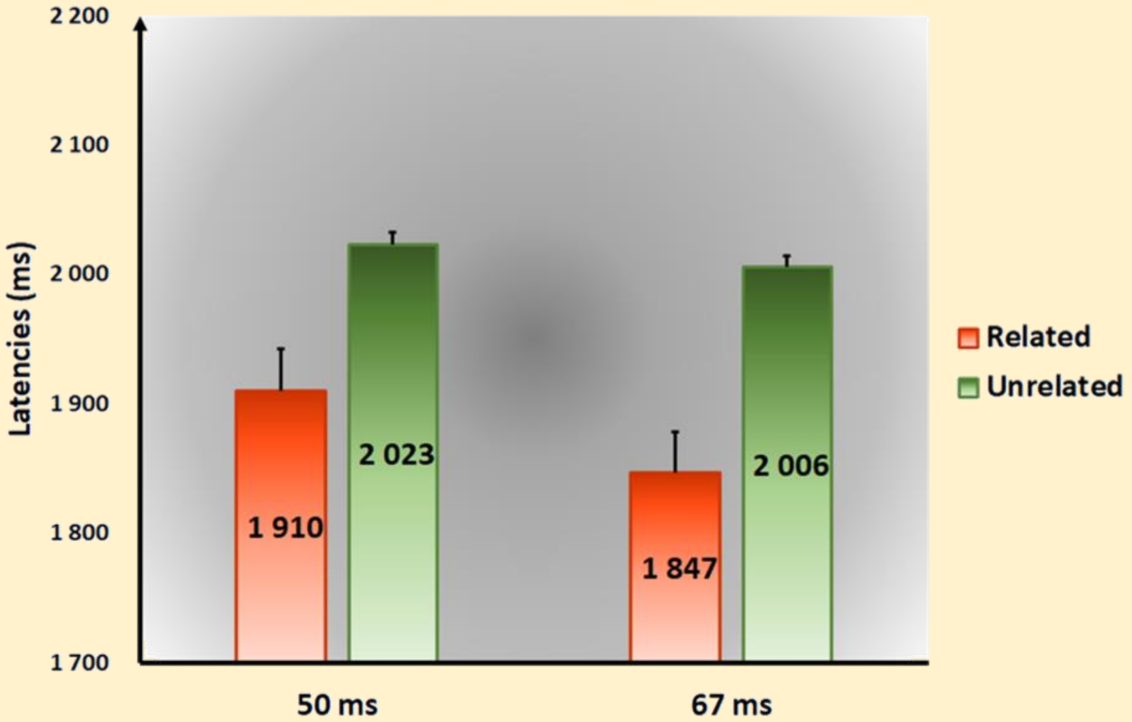

Figure 72. Raw data of latencies – English typical-reader university students - Experiment 5.

8.3.2.3.Analysis of latencies.

Final model formula:

The final LMM fitted to the RTs of each participant for each correct word trial included by-participant and by-target random intercepts, and Prime-type (Related vs. Unrelated), SOA (50 vs. 67 ms) and their interaction as fixed effects (best model according to the AIC). Those fixed effects explained 10% of the variance (marginal R^2 = .098).

RTs were significantly lower with the longest SOA (67 milliseconds – 1925 ms, SD = 237) than the shortest SOA (50 milliseconds – 1967 ms, SD = 236), and for related primes (1878 ms, SD = 237) than for unrelated primes (2015 ms, SD = 217), with a priming effect of 137 milliseconds. Critically, the interaction between Prime-type and SOA was significant, latencies being lower for related primes than unrelated primes, with higher amplitude of this priming effect with an SOA at 67 ms (amplitude of 159 ms), compared to an SOA at 50 ms (amplitude of 113 ms).

The parameter estimates of the final model fitted to the RTs, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[119], are reported in Table 58 below.

Table 58. Parameter estimates of the final model fitted to the RTs (**and output from the Bayesian analysis in bold**) – French typical-reader university students - Experiment 5.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	1912	19	98.92	<.001*	**1887**	**9**	**[1870;1905]**
Prime-type	117	9	13.40	<.001*	**138**	**6**	**[126;150]**
SOA	-65	23	-2.83	<.01*	**11**	**6**	**[-.91;23.64]**
Prime-type x SOA	47	12	3.85	<.001*	**65**	**7**	**[50;79]**

Note: Significant effects at a p < .05 level are marked with a ∗*. Final model formula: glmer(RT ~ Prime_type * SOA+ (1 | Participant) + (1 |Target), data = Data_RT_words_Exp5_Frcntrluniv, family = gaussian)*

8.3.3. Interaction between Prime-type and Group.

There were no middle-schoolers included into the final analysis. Therefore, we directly compare French and English university students, with mixed-effect modelling, including SOA, Prime-type, Group and their interactions as fixed factors.

Final model formula:

The final LMM fitted to the RTs of each participant for each correct word trial included by-participant random intercepts and random slopes considering the Prime-type, by-target random intercepts, and SOA, Prime-type (Related vs. Unrelated) , Group (English students vs. French students) and the two-way interaction between SOA and Prime-type as fixed effects (best model according to the AIC: $F(1,106.89) = 30.25$, $p < .001$). Those fixed effects explained 14% of the variance (marginal $R^2 = .137$).

RTs were significantly lower with the longest SOA (67 milliseconds – 1959 ms, SD = 271) than the shortest SOA (50 milliseconds – 2012 ms, SD = 261), and for related primes (1910 ms, SD = 265) than for unrelated primes (2063 ms, SD = 247), with a priming effect of

[119] Maximum BF = 3.468 * 10^92, corresponding to the same model formula than those of the final model of LMM (bayes_R² = .27, SE = .01, 95% CrI = [.25, .29]).

153 milliseconds. Critically, the interaction between Prime-type and SOA was significant, latencies being lower for related primes than unrelated primes, with higher amplitude of this priming effect with an SOA at 67 ms (amplitude of 185 ms), compared to an SOA at 50 ms (amplitude of 115 ms). In addition, Group effect was significant, English students being faster than French students.

The parameter estimates of the final model fitted to the RTs, as well as the output from the Bayesian analyses corresponding to the best model according to the BF[120], are reported in Table 59 below.

Table 59. Parameter estimates of the final model fitted to the RTs (**and output from the Bayesian analysis in bold**) – Experiment 5.

Predictors	b	SE b	t	p	**b**	**SE b**	**95% CrI**
(Intercept)	2003	14	139.13	<.001*	**2005**	**14**	**[1978;2032]**
SOA	59	20	-2.96	<.01*	**37**	**21**	**[-79;5]**
Prime-type	158	11	14.43	<.001*	**123**	**8**	**[107;138]**
Group	-108	20	-5.50	<.001*	**-20**	**9**	**[-37;-.50]**
SOA x Prime-type	76	22	3.47	<.001*	**150**	**16**	**[118;183]**

Note: Significant effects at a p < .05 level are marked with a ∗. Final model formula: glmer(RT ~ SOA + Prime_type + Group+ SOA:Prime-type + (1 Prime-type | Participant) + (1 |Target), data = Data_RT_words_Exp5, family = gaussian)

8.4. Discussion.

Experiment 5 aimed to determine if bilingual individuals could benefit from the pre-activation of the lexical representation of an L2 written word when recognizing the same word in oral modality. To do so, the current study analysed the impact of cross-modal repetition of L2[121] words, at the item level. Table 60 page 238 presents a brief summary of the results of

[120] Maximum BF = 1.02 * 10^210, corresponding to the same model formula than those of the final model of LMM (bayes_R^2 = .39, SE = .01, 95% CrI = [.38, .40]).

[121] Including also a control group in L1.

each group. Then, a simple interpretation of those results will be proposed, the last section of this manuscript being devoted to a theoretical discussion of all experiments.

Table 60. Summary of the results - Experiment 5 – all groups.

(R = Repetition corresponding to Prime-type effect, P = L2 Proficiency, C = Cognateness, G = Group, ✓ = significant effect, ✗ = non-significant effect)

Group	SOA	R	P	C	G	SOA:R	SOA:C
French students	✓	✓	✓	✗	NA	✓	✓
English students	✓	✓	NA	NA	NA	✓	NA
All	✓	✓	NA	NA	✓	✓	NA

8.4.1. First hypothesis: Priming effect among French students, with larger amplitude for the longest SOA.

We highlighted the expected priming effect, with lower latencies for repeated words compared to non-repeated words. This indicated that the cross-modal repetition of L2 words improved their spoken recognition among intermediate proficiency late bilinguals, at the item level. The connections between orthographic and phonological lexical representations in L2 were robust enough to allow a faster recognition of repeated spoken words compared to non-repeated ones, at the item level. This finding demonstrated that recognizing an English written word activates a lexical representation, which intermediate proficiency bilingual participants use for secondary and immediate spoken word recognition. Therefore, when they hear the same word they had just seen, they recognize it faster, its lexical representation being pre-activated. This is congruent with the findings of previous experiments at the level of lists, as with the Multilink model proposing bidirectional links between orthographic and phonological representations of words (Dijkstra et al., 2019).

Furthermore, as anticipated, this priming effect was of larger amplitude for the group having an SOA at 67 milliseconds, compared to the group having an SOA at 50 milliseconds. This larger amplitude was due to a faster recognition of repeated words for the longest SOA, compared to the shortest SOA (*cf.* raw data). Note that the latencies of non-repeated word recognition were similar for both SOA (*cf.* raw data). This finding demonstrated the phonological processing, occurring if SOA is long enough. Indeed, because words were processed phonologically for the group with an SOA at 67 milliseconds, their phonological lexical representations were more activated (*i.e.*, the level of activation was higher) compared to those of the group with an SOA at 50 milliseconds, accelerating their secondary spoken word recognition. This is congruent with the literature in the field, showing orthographic priming for short SOA and phonological priming for long SOA (see notably: Ferrand & Grainger, 1994; Grainger et al., 2003).

8.4.2. Second hypothesis: Priming effect among French middle-schoolers, with lower amplitude than university students.

This experiment being too difficult for middle-schoolers, we had to exclude from the analysis a huge part of the sample, performing the task randomly. Even if this experiment involved more frequent items than Experiment 1, it is congruent with the results of this previous experiment. Indeed, French middle-schoolers of Experiment 1 showed a modality effect in favour of the written modality, with lower performances in oral modality, corresponding to random responses. The current experiment implying only L2 spoken word recognition, middle-schoolers performed this task randomly, preventing any interpretation of results.

8.4.3. Third hypothesis: Cognate word interferences with the priming effect.

In the current experiment, we highlighted a cognate effect on spoken word recognition, only for the shortest SOA (*i.e.*, 50 milliseconds). This finding is congruent with the results of Experiment 1, demonstrating a double-sided cognate effect: facilitating in written modality, but inhibitory (or at least with no effect) in oral one. Indeed, Experiment 5 involving spoken word recognition only, there was globally no cognate effect. Note that the lack of inhibitory effect in Experiment 5 could be due to lexical frequencies, higher in this experiment compared to the first one, responsible for higher resting level activation, hampering somehow the observation of an inhibition.

Nevertheless, the cognate effect, with cognate words faster recognized than non-cognate ones was observed for the shortest SOA, but not for the longest one. This finding demonstrated that, when prime duration is long enough to allow a phonological processing, the phonological lexical representation thus pre-activated did not allow an acceleration of the recognition of spoken cognate words, the latter being recognized as non-cognate words. Conversely, when prime duration is too short, precluding any phonological processing, no phonological representation was pre-activated, leading to the possibility for bilinguals to recognize spoken cognate words faster than non-cognate ones. This result is particularly interesting, because it indicates that orthographic and phonological lexical representations of cognate words are not connected among intermediate proficiency participants. Therefore, cross-modal repetition priming with short SOA precluding phonological processing pre-activates an orthographic lexical representation not connected to a phonological one, leading to a spoken word recognition without interference. On the contrary, cross-modal repetition priming with long SOA allowing phonological processing pre-activates an orthographic lexical representation and a phonological one, non-connected with each other, the latter leading to an interference during spoken word recognition.

Furthermore, when analysing cognate words, Experiment 5 demonstrated the absence of cognate-type effect. Identical and Non-identical cognate words were recognized as faster, whatever the SOA. This is congruent with the interpretation proposed above, the amount of orthographic overlap being unable to impact the priming effect, the connection between orthographic and phonological lexical representations of cognate words being inexistant.

8.4.4. Fourth hypothesis: Proficiency effect in both French groups, and interaction between Proficiency and SOA.

The current study highlighted the expected L2 proficiency effect, the highest proficiency participants being faster to recognize L2 words than the lowest proficiency participants. This demonstrated that the lexical access in L2 depends on the level of proficiency in this language, given that this proficiency is related, at least partially, to the exposure to this language. The lowest proficiency participants were expected to have less encountered each item, and thus to take more time to access to lexical representations of English words. This result is congruent with the Multilink model, in which L2 proficiency is took into account trough the resting level activation (Dijkstra et al., 2019).

Note that, this proficiency effect was highlighted for the group of French university students whatever the SOA, with no interaction between L2 Proficiency and SOA included into the final model. However, this lack of interaction could be linked with a lack of statistical power, because of the number of factors included into the model. Post-hoc analysis demonstrated that this interaction existed, with a proficiency effect only for the longest SOA, as expected. This finding suggests that the proficiency effect depends on the possibility for the participants to process the stimuli phonologically. In other words, the phonological information is more disadvantageous for the lowest proficiency bilinguals. Thus, for the shortest SOA, all participants, whatever their L2 Proficiency, were not able to process phonologically L2 words, having not enough time. Consequently, the results displayed no proficiency effect. However, for the longest SOA, the highest proficiency participants had enough time to process L2 words phonologically, while this processing was more difficult for the lowest proficiency participants. Thus, the highest proficiency participants were able to access to the phonological lexical representations of words, while the lowest proficiency participants were not. Therefore, this inter-dependency between phonological processing and proficiency effect corresponded to strong connections between L2 proficiency on the one hand and the robustness of the links between orthographic and phonological lexical representations in L2 on the other hand. In other words, whatever their proficiency, bilingual participants had similar latencies in the group with an SOA at 50 milliseconds, because they were too long to recognize L2 spoken words and thus to access directly to their phonological representations. Conversely, bilinguals in the group with an SOA at 67 milliseconds had longer latencies when they were from lower proficiency, compared to the participants from higher proficiency, indicating that the highest proficiency participants had more robust links between orthographic and phonological representations of L2 words, and were thus able to pre-activate the phonological representations of those words following their written recognition, while the lowest proficiency participants were not. Note that L2 Proficiency was more homogeneous in the group with the shortest SOA, which could also explain the lack of Proficiency effect highlighted among this group, and necessitate to be cautious concerning this interpretation.

Critically, there was no interaction between L2 proficiency and Prime-type. In other words, the amplitude of the priming effect did not depend on L2 Proficiency. This lack of effect could be due to a lack of statistical power, given that a non-negligeable part of the sample needed to be excluded from the analysis due to random responses, reducing the heterogeneity of L2 proficiency in the analysed group of participants. Future research is needed to further analyse this interaction.

8.4.5. Fourth hypothesis: Priming effect in L1 English, with larger amplitude for the longest SOA, and larger amplitude than that in L2.

Finally, English typical-reader university students presented the expected priming effect in L1, from a larger amplitude for the longest SOA (67 milliseconds), compared to the shortest SOA (50 milliseconds). This finding demonstrated their ability to process phonologically L1 words when they have enough time to perform this processing, as for French students in L2.

Furthermore, English students performing the task in L1 were faster to recognize English words than French students performing the task in L2, which could be related to their proficiency in this language. Indeed, this group effect existed for both SOA.

Finally, an interaction between group and Prime-type was highlighted only with the longest SOA (67 milliseconds). Indeed, English students were faster to recognize English words than French students, with a larger amplitude of the priming effect when the SOA was long (67 milliseconds) compared to the short one (50 milliseconds). This result demonstrated the higher ability of English students to process phonologically English written words, compared to French students, and therefore to pre-activate the associated phonological lexical representations, allowing to accelerate their secondary spoken recognition. This finding seems logical given that English students performed the task in L1. However, it is also surprising, considering that English students presented a modality effect in favour of the written one in L1 word recognition accuracy (*cf.* Experiment 2). However, it indicates that even if their L1 phonological lexical representations benefit from relatively high resting level activations, they are not easy to access for them, given the inconsistency of English language orthography. Therefore, it would be interesting to take into account which languages are considered when discussing about bilingual models, given that each language had its own features, impacting word recognition differently across languages.

8.4.6. Limitations.

There are some limitations to this study, such as the fact that it was too difficult for middle-schoolers, precluding any interpretation of their data. Furthermore, the experimental design used in the current experiment analysed cross-modal repetition effect from written to oral modalities only. It could be interesting to compare both written-to-oral and oral-to-written cross-modal repetition effects. However, even if it is theoretically easy to understand this kind of oral-to-written paradigm, it would be technically difficult to set up and would need notably masked oral primes.

8.5. Conclusion.

In conclusion, our results argued in favour of the existence of connections between orthographic and phonological lexical representations in English, which robustness depends on lexical frequencies and consequently on English proficiency and exposure. This was notably highlighted through the impossibility to interpretate middle-schoolers data, due to their random performances, linked with their low L2 proficiency. Those connections facilitate spoken word recognition at the item level. However, further research needs to explore those links, through different configurations of this paradigm – in order to test notably the bi-directionality of those connections. Considering those results and the incongruence between French and English OPM, the question then arises as to the activation of L1 orthographic knowledge – easier to access for (low to) intermediate proficiency bilinguals – during L2 spoken word recognition.

The following section will be devoted to a theoretical discussion concerning all findings of this project, regarding bilingual models of word recognition.

General discussion

This thesis work aimed at establishing a basis for the research on the impact of modality on L2 word recognition, the first stage of word processing. Indeed, this crucial mechanism has been extensively investigated throughout the literature, but considering only one modality at once during task completion. Yet, the main models of bilingual word recognition assumed direct connections between orthographic and phonological lexical representations (Dijkstra et al., 2019; Dijkstra & van Heuven, 2002). Note that the BIA-d model does not contain an explicit interaction between modalities, this model describing the development of written lexical knowledge, despite the fact that it could be applied to spoken word recognition according to its authors themselves (Grainger et al., 2010). In this framework, the general objectives of this thesis project were thus:

1. to evaluate the impact of modality on L2 word recognition accuracy among adult late L2 learners from a large range of L2 proficiency, notably through the analysis of cognate word recognition, those words being especially interesting given the challenge they represent for the word recognition system with their orthographic more than phonological between-language similarities;
2. to highlight an evolution of this modality effect with L2 proficiency increase, through a cross-sectional perspective, comparing university students and middle-schoolers;
3. to determine how reading efficiency in L1 interacts with modality effect in L2, by comparing typical and dyslexic-readers;
4. to analyse the extent to which L2 lexical representations, both orthographic and phonological, are connected and able to influence each other’s resting level activation.

We will firstly and briefly outline the main results obtained for each of the experiments in this thesis. We will secondly confront those results with the literature, and in particular with the most relevant bilingual models of word recognition, namely the BIA-d and Multilink models (see section 2.3.3 page 50 for the reasons explaining why we focus on those models in particular; Dijkstra et al., 2019; Grainger et al., 2010). Indeed, it seems crucial, although this has not yet been clearly established, to determine the extent to which those models are appropriate for the understanding of the mechanisms underlying bilingual word recognition, notably among the specific population of French-English late bilinguals with and without developmental dyslexia. Then, we will propose an adaptation of the existing models, taking into account the various parameters influencing word recognition among late bilinguals, as revealed by the main findings of the current project. Finally, we will present the major limitations of this project, which must be kept in mind for the interpretation of those results, and consider the theoretical and practical implications of its findings.

1. Reminder of the main objectives and findings of each experiment.

Let us start with a brief overview of the main findings of this project. A summary of the main results obtained in the framework of this thesis is presented in Table 61 page 248 (corresponding to the table entitled "summary of all results" on which we referred throughout this manuscript).

Experiment 1 investigated the extent to which the accuracy of the first stage of word processing, namely word recognition accuracy, is sensitive to modality among late bilinguals. This experiment took into consideration L2 proficiency, L1 reading efficiency and language features on the one hand, and adopted a cross-sectional perspective on the other hand. We highlighted the expected **modality effect, in favour of the written modality**, **among typical-readers, both French and English native-speakers.** Therefore, written L2 words were more

Table 61. Summary of all results.

Experiment	Design	Participants	Task	M	S	P	G	C	M:S	M:P	M:G	M:C	S:G	M:S:P	M:S:G
Experiment 1: Does modality matter in L2 word recognition accuracy?	LDT in both modalities, counterbalanced order or presentation of modalities	French university students, typical-readers (N = 47)	Non-cognate task (I = 43 words)	√	X	√	NA	NA	X	X	NA	NA	NA	X	NA
			Cognate task (I = 58 words)	√	X	√	NA	√	X	√	NA	√	NA	X	NA
		French university students, typical and dyslexic-readers (N = 17 *vs.* 17)	Non-cognate task (I = 43 words)	√	X	√	X	NA	X	√	X	NA	√	√	X
			Cognate task (I = 58 words)	√	X	√	√	√	X	√	√	√	X	X	√
		French middle-schoolers, typical-readers (N = 42)	Non-cognate task (I = 40 words)	√	X	√	NA	NA	X	X	NA	NA	NA	X	NA
			Cognate task (I = 60 words)	√	√	√	NA	√	X	X	NA	√	NA	X	NA
		French middle-schoolers, typical-readers (N = 17 *vs.* 17)	Non-cognate task (I = 40 words)	√	X	X	X	NA	X	X	X	NA	X	X	X
			Cognate task (I = 60 words)	√	X	X	√	√	X	X	√	√	X	X	X
		English university students, typical-readers (N = 29)	Cognate task (I = 60 words)	√	X	√	NA	√	X	X	NA	√	NA	X	NA

Experiment	Design	Participants	M	S	G	M:S	M:G	S:G	M:S:G
Experiment 2: Does modality matter in L1 word recognition accuracy?	LDT in both modalities, counterbalanced order or presentation of modalities	French university students, typical-readers (N = 48, I = 36)	X	X	NA	X	NA	NA	NA
		French university students, typical and dyslexic-readers (N = 17 *vs.* 17, I = 36)	X	X	X	X	X	X	X
		French middle-schoolers, typical-readers (N = 46, I = 30)	X	X	NA	X	NA	NA	NA
		French middle-schoolers, typical-readers (N = 17 *vs.* 17, I = 30)	X	X	X	X	X	X	X
		English university students, typical-readers (N = 38, I = 39)	√	X	NA	X	NA	NA	NA

Experiment	Design	Participants	Modality	In L2 English: P	G	IT	In L1 French: G	IT
Experiments 3 and 4: Impact of cross-modal repetition on word recognition latencies.	LDT in one modality in exposition phase and in the other in test phase, counterbalanced modalities accross participants, 40 repeated and 40 non-repeated words in test phase	French university students, typical-readers (N = 75 in L2 and 86 in L1)	Written	X	NA	√	NA	X
			Oral	X	NA	√	NA	X
		French university students, typical and dyslexic-readers (N = 20 vs. 20)	Written	X	√	X	√	X
			Oral	X	X	√	X	X

Experiment	Design	Participants	SOA	R	P	C	G	SOA:R	SOA:C
Experiment 5: Impact of cross-modal repetition priming on L2 word recognition.	Masked cross-modal repetition priming, with written primes and spoken targets, with SOA at 50 or 67 ms counterbalanced across participants	French university students, typical-readers (N = 44 with SOA at 50 ms and 44 with SOA at 67 ms, I = 120)	√	√	√	X	NA	√	√
		English university students, typical-readers, monolinguals (N = 30 with SOA at 50 ms and 30 with SOA at 67 ms, I = 120)	√	√	NA	NA	NA	√	NA
		Both English monolinguals and French-English bilinguals, university students, typical-readers	√	√	NA	NA	√	√	NA

N: Number of participants, I: Number of items, M: Modality, S: Session, P: L2 Proficiency, G: Group, C: Cognateness / Cognate-type, IT: Item-type, R: Repetition

√ Significant effect X Non-significant effect accurately recognized than L2 spoken words. Furthermore, it demonstrated a **double-sided cognate effect: facilitatory in written modality, and ambiguous in oral one.** Besides, **L2 word recognition accuracy depended on L2 Proficiency**. In addition, this first experiment was exploratory concerning the session effect, which would indicate a benefit from one modality over the other one. In Experiment 1, **no session effect** could be evidenced. Finally and surprisingly, **dyslexic-readers** presented the same pattern of results than typical-readers, with a **modality effect in favour of the written modality**. Moreover, a group effect was highlighted on cognate word recognition accuracy only, with an interaction between modality and group effects. Actually, **dyslexic-readers presented lower accuracy scores than typical-readers in written modality but not in oral one**.

Experiment 2 aimed to test whether this modality effect demonstrated on L2 word recognition accuracy in Experiment 1 also exists in L1. We observed **no modality effect in French L1 word recognition,** while **a modality effect in favour of the written one** was found **in English L1 word recognition.** Besides, this experiment reported **no session effect**, neither in English or in French languages. Therefore, there was no benefit from one modality over the other in L1. Finally, we failed to observe a group effect, **dyslexic-readers** recognizing L1 words **as accurate**ly **as typical-readers**.

In order to overcome the lack of latency analysis in previous experiments, Experiment 3 was designed to assess the robustness of the links between orthographic and phonological lexical representations in L2 among late bilinguals, through an analysis of latencies. For this purpose, Experiment 3 evaluated the degree of impact of cross-modal lexical repetition on L2 word recognition latencies (in a paradigm with an exposition to words in one modality during a first phase and a test phase in the other modality with repeated and non-repeated words). This experiment revealed a **cross-modal lexical repetition effect**, with repeated words faster recognized than non-repeated words, **whatever the modality of the test phase**, which corresponded to a kind of session effect (as defined in Experiments 1 and 2). In addition, we observed **no L2 Proficiency effect on L2 word recognition latencies**. Finally, **dyslexic-readers** presented also a **cross-modal lexical repetition effect**, with repeated words faster recognized than non-repeated words, but **only from written to oral modality**, whereas they were **slower than typical-readers** to recognize words **in written modality only**.

Considering the difference observed between French and English native-speakers in Experiment 2, Experiment 4 aimed to control in L1 the results obtained in L2 in Experiment 3. Although **dyslexic-readers** were also **slower than typical-readers** to recognize L1 words **in written modality**, this experiment did not reveal any other significant result. In particular, there was **no cross-modal repetition effect in L1**, neither in French or in English languages.

Finally, previous experimental protocols allowing an investigation of the various issues of this project at the level of the list only, Experiment 5 was designed to explore those issues at the item level. This experiment thus focused on the exploration of the extent to which late bilinguals could benefit from the pre-activation of L2 orthographic lexical representation when recognizing the corresponding word in oral modality. To do so, a masked cross-modal repetition priming paradigm was implemented, with written primes and spoken targets, both in L2, including a comparison of short and long SOA[122], and including cognate and non-cognate words. **French-English late bilinguals** were **faster** to recognize English spoken words **when primes were presented with the long SOA**. Furthermore, they presented a **priming effect**, latencies being lower for related primes than unrelated primes, **from higher amplitude** when primes were presented with the **long SOA** compared to the short SOA. Interestingly, **English monolinguals** presented **exactly the same pattern of results**, except that they were globally

[122] SOA = Stimulus Onset Asynchrony.

faster than French-English bilinguals. Besides, among French-English late bilinguals, a **cognate effect**, with cognate words faster recognized than non-cognate words, existed when primes were presented with **the short SOA**, but not with the long SOA.

We will now confront those results with the literature, and notably the BIA-d and Multilink models (Dijkstra et al., 2019; Grainger et al., 2010). For greater clarity and succinctness, we propose to firstly deal with the issues concerning typical-reader late bilinguals, in order to determine the extent to which those models could be applied, or need to be adapted, to the specific population of late bilinguals. We will also deal with the issue of the impact of language features, *via* the comparison of findings among French and English native-speakers. Secondly, we will detail how the current project could provide some answers as to the question of the application or adaptation of those models to dyslexic-reader late bilinguals.

2. Word recognition among typical-reader late bilinguals.

L2 word recognition is a particular processing, which depends on various parameters, such as L2 proficiency or cross-language similarities (see notably: Dijkstra et al., 2010; Veivo & Järvikivi, 2013). In addition, language features, as well as L1 background, could also influence word processing (Muljani et al., 1998; Sauval et al., 2018). Finally, because L2 words can be learned *via* the oral modality as well as *via* the written modality, through the implicit exposure through medias notably, it is important to understand how the access to lexical information inscribed into the mental lexicon through one modality can – or not – transfer to the other modality. The following sections will be devoted to the confrontation of the main findings of the current project with the literature concerning these different parameters, and notably with the psycholinguistic models.

2.1. On the impact of word presentation modality.

Critically, one of the major findings of this project concerns the impact of the modality (written *vs.* oral) on L2 word recognition accuracy. Interestingly, the present work demonstrated the existence of a modality effect in L2, in favour of the written modality, among French-English late bilinguals (Cornut et al., 2021), either university students or middle-schoolers (Experiment 1). The same modality effect in L2 was also observed among English-French university students (Experiment 1), which tends to indicate that an alphabetic language (English as French languages in the current project) provides this kind of modality effect in L2 among late bilinguals having learned this language in an academic context.

Such a modality effect has already been reported on word recognition latencies, written word recognition being faster than spoken one (Ferrand et al., 2018). More, priming studies demonstrated the temporality of word processing, with notably orthographic processing occurring earlier than phonological one during written word recognition (Grainger et al., 2003). That probably explains why most bilingual models of word recognition focused on written word recognition, such as the BIA-d and Multilink models (Dijkstra et al., 2019; Grainger et al., 2010), even if the BIA-d model could be applied to spoken word recognition, according to its authors themselves, and if the Multilink model involves a phonological component. However, to our knowledge, there was no experiment examining this question of the impact of modality concerning L2 word recognition accuracy. Note that the modality effect we highlighted is congruent with the results of Veivo's team, who demonstrated the existence of a modality effect on L3 word translation accuracy, among Finnish learners of French (Veivo, 2017; Veivo et al., 2015). Nevertheless, the translation task necessitates a semantic processing, which is of a higher level of complexity than word recognition.

Importantly, this thesis work focused on word recognition among the specific population of late bilinguals characterised notably by an unbalanced bilingualism resulting from an academic L2 learning. Therefore, those L2 learners being already exposed to both oral and written modalities in their L1, their lexical processing would be influenced by their literacy, in both languages, which consisted in their ability to decode words, and thus to access to the phonological form of words from the exposure to their associated orthographic form, through the specific OPM corresponding to the belonging language of those words. Nevertheless, although numerous studies analysed the consequences of bilingualism in general, very little information is available concerning word recognition among low-to-intermediate proficiency late bilinguals, and even less about English learned by students living in an L1-based environment and characterized by an English exposure mainly limited to school didactic situations (Łockiewicz et al., 2020).

Furthermore, word recognition has been extensively investigated, in both L1 and L2, considering each modality independently (Ferrand et al., 2010; Marian et al., 2008; Oganian et al., 2016; van Heuven et al., 1998), given that the mechanisms of word recognition were known to be qualitatively different depending on the modality: lexical in written modality, because of the availability of the whole written stimuli simultaneously, and sub-lexical in oral modality, because of the temporality of spoken stimuli. Therefore, it seems difficult to analyse both modalities together, and mostly to compare word recognition between modalities, given that those differences in the associated activation mechanisms result in huge differences in the corresponding behavioural measures (see notably for the relatively low correlation between written and spoken word recognition latencies: Ferrand et al., 2018). That is why the current project implemented specific experimental designs allowing a comparison of word recognition accuracy across modalities. Note that the modality effect outlined with this project is consistent with those different activation mechanisms depending on the modality described above among typical-readers (Coltheart, 2001; Klatt, 1980; McClelland & Elman, 1986a, 1986b; Morais, 2010), but could also be related to the specificities of L2 learning in an academic context, responsible for a bias in exposure in favour of the written modality.

Crucially, it should be noted that the BIA-d and Multilink models (Dijkstra et al., 2019; Grainger et al., 2010), do not take this modality effect into account, describing written word recognition only. Concerning the BIA-d model, its authors declared that it could be applied to spoken word recognition too. But, even if it is possible, it would not provide any information concerning this modality effect. Nevertheless, the fact that L2 lexical representations seem modal-dependent is crucial during word recognition, and suggests the possibility to adjust this type of model, in particular to account for the modality effect presented in L2 by intermediate proficiency late bilinguals. We thus propose to improve those interactive models, through their adaptation to **both written and spoken** word recognitions (see our proposition of a new model at the end of this general discussion). This kind of model would thus allow two possible types of inputs: either visual or auditive. It would also **simulate the modality effect in favour of the written one**, through different weights affected to each connection between the inputs and their corresponding orthographic and phonological nodes.

Because L2 word recognition depends notably on L2 proficiency (Veivo & Järvikivi, 2013), we will now discuss on this parameter.

2.2. On the impact of L2 Proficiency.

Besides, we found a proficiency effect on rare word recognition accuracy (Experiment 1), while we did not find it on frequent word recognition latencies (Experiment 3). These opposite results demonstrate the importance of taking into account, not only the subjective frequency of each word, but also the objective – and adapted depending on the participants –

frequency during word recognition. This objective frequency is therefore a major parameter, needing to be adapted for late bilinguals – rather than using that proposed in monolingual databases, notably *via* the data provided by some databases like that of the APPREL-2 ANR project. This kind of project is thus crucial to carry out, in different languages, and if possible, in written as in oral modalities.

Interestingly, some models take already into account L2 Proficiency, notably through the subjective frequency. For example, the BIA-d model is a developmental model which describes the evolution of the organization of the bilingual mental lexicon when L2 proficiency increases (Grainger et al., 2010). Likewise, the Multilink model integrates L2 proficiency in the resting level activation of each word node, through the subjective frequency of each word, using an arithmetic definition of the distance between two words with diverse frequencies (Dijkstra et al., 2019). Those models therefore account for the proficiency effect outlined on word recognition accuracy by previous studies (Diependaele et al., 2013; Veivo, 2017; Veivo et al., 2015; Veivo & Järvikivi, 2013), but they do not consider the objective frequency corresponding to the specific population of late bilinguals. We therefore propose to adapt for late bilinguals the **formula for the calculation of the resting level activation of each word node** (see our proposition of a new model at the end of this general discussion), by including the data of databases, such as that Ronald Peereman will develop in the APPREL-2 ANR project.

Critically, we found also an interaction between L2 proficiency and modality on L2 word recognition accuracy, among French-English university students. We failed to highlight this interaction in the other groups (French middle-schoolers and English-French university students), which tends to indicate that this interaction is unclear and need further exploration. Nevertheless, the fact that the French university student group is more proficient in L2 than the other groups is probably a key information to explain why we observed this interaction in this group only. Indeed, French university students have been identified as intermediate proficiency bilinguals, with a mean Dialang Level score of 679 out of 1,000 (SD = 161), while the participants of Veivo et al. experiments (2015) were spread from B1 to C2 levels of proficiency according to the Common European Framework of Reference (Council of Europe, 2001). Those two groups could thus be considered as intermediate or intermediate-to-high proficiency late bilinguals. On the contrary, French middle-schoolers and English university students have been labelled as low proficiency bilinguals, with a mean Dialang Level score of respectively 338 out of 1,000 (SD = 189) and 231 out of 1,000 (SD = 149). The main difference between low and intermediate L2 proficiency groups, in terms of L2 word recognition accuracy, concerned mainly spoken word recognition, which was performed randomly by most of low proficient bilinguals, while written word recognition seemed to be less accurate for the lowest proficiency bilinguals compared to the highest proficiency bilinguals, but not corresponding to random performances. Therefore, those results were congruent with the finding of Veivo's team (2015), who outlined an interaction between L3 proficiency and modality on L3 word translation accuracy, the amplitude of the modality effect (*i.e.*, the difference in accuracy scores between written and oral modalities) being larger for the lowest proficiency bilinguals, compared to the highest proficiency bilinguals. We propose to consider this interaction between modality and L2 Proficiency, through the **adaptation of the weights affected to each connection between L2 language node and both orthographic and phonological L2 lexical representations, differently for each modality, depending on L2 Proficiency**.

Given those two main findings (*i.e.*, the modality effect and its interaction with L2 proficiency), the question then arises logically of cognate word processing.

2.3. On the specificities of cognate word recognition.

The current project confirmed somehow the existence of a cognate facilitation effect, which is congruent with the extensive literature on this topic (see for a review: Lauro &

Schwartz, 2017). However, we demonstrated that it is crucial to take into consideration the modality and the L2 proficiency when dealing with cognate word recognition. Indeed, to our knowledge, this project was the first to directly compare L2 cognate word recognition across modalities. It demonstrated the existence of a double-sided cognate effect depending on the modality. Indeed, the first experiment found a cognate effect on L2 word recognition accuracy, which interacts with the modality. This cognate effect was clearly facilitating in written modality among French-English late bilinguals, either university students and middle-schoolers, and among English-French late bilinguals. On the contrary, the cognate effect was more ambiguous in oral modality, notably depending on L2 Proficiency. Actually, it was completely absent among English-French bilinguals, whereas French-English bilinguals displayed different results depending on L2 Proficiency. A complete orthographic overlap was inhibitory among French-English university students – *i.e.*, intermediate proficiency late bilinguals, while a cognate facilitation effect was observed in oral modality, but from a narrower amplitude than in the written modality, among French-English middle-schoolers – *i.e.*, low proficiency late bilinguals. This is congruent with the findings of Dijkstra et al. (2010), who highlighted that accuracy and latencies of word recognition depend on the amount of orthographic overlap, with identical cognate words faster and more accurately recognized than non-identical ones.

Therefore, the cognate effect seems modal and proficiency-dependent: clearly facilitating in written modality (see notably for the cognate facilitation effect in written modality among beginner learners of L2 – primary-school and middle-school students: Brenders et al., 2011), but particularly conditioned by L2 Proficiency in oral modality. This is in line with the fact that cognate words are particularly challenging for spoken word recognition system. Actually, Dijkstra and van Heuven (2002) demonstrated that orthographic, phonological and semantic representations are automatically co-activated during L2 word recognition, while their activations are specifically distributed on a temporal level. In addition, Veivo and Järvikivi (2013) outlined that orthographic representations are automatically activated during spoken word recognition, in both L1 and L2. Therefore, cognate words, associated with different phonological forms in both languages, would lead to huge interferences during L2 spoken word recognition. This is also consistent with the results of the last experiment, based on a repetition priming paradigm, which analysed the cognate effect on spoken word recognition among intermediate proficiency bilinguals. This study demonstrated that cognate effect depends on prime duration, and thus on the possibility for intermediate proficiency bilinguals to process written words phonologically. With the short SOA, preventing any phonological processing of primes, a cognate facilitation effect was demonstrated, whereas it was absent with the long SOA, the phonological processing of the written primes hampering the secondary spoken word recognition among intermediate proficiency late bilinguals, which is consistent with the importance of phonological information for lexical competition (Chéreau et al., 2007; Marian & Spivey, 2003; Spivey & Marian, 1999; Veivo, 2017; Veivo et al., 2016).

Given those specificities of cognate words, their processing is of major interest, in both modalities. However, there were few studies analysing cognate word processing in oral modalities, and even fewer comparing it across modalities. In 2019, Dijkstra et al. designed nonetheless the Multilink model, notably to implement cognate processing. This model included an integrated lexicon for both L1 and L2 languages, allowing a cross-language lexical competition between orthographic neighbours (van Heuven et al., 1998), providing therefore the simulation of both cognate and non-cognate word recognition. These model simulations lead to the well-known cognate facilitation effect, cognate word orthographic representations spreading activation to their associated phonological representations in both languages, which send congruent activation to their shared semantic representations (Dijkstra et al., 2010). This cognate facilitation effect was integrated in the model through a specific formula precluding an overestimation of the cognate effect. The authors themselves admitted that further exploration of this point of interest were needed.

In the present form, this model is not able to account for the double-sided characteristic of this cognate effect, according to the modality, cognate spoken word processing not being taken into consideration. We therefore suggest to add this parameter in the adapted model proposed further, by **distinguishing the formulae applied to connections between both orthographic and phonological forms of cognate words depending on their direction**, in order to account for the interaction between modality and cognate effects. In addition, in order to take into consideration the amount of orthographic overlap between translation equivalents – and thus globally the cognateness, a **distinction in the formulae associated with cognate and non-cognate words** on the one hand, and with **identical and non-identical cognate words** on the other hand, would be also added. We propose also to take into consideration the interaction between L2 proficiency and cognate effects by the addition of an **inhibitory connection between L1 language node and the connection between orthographic and phonological representations of cognate words, which weight depends on L2 proficiency**.

Considering that cognate words are defined regarding two languages (the L1 and the L2 of a given bilingual), it is crucial to deal with the issue of the influence of L1 on L2 word recognition on the one hand (Muljani et al., 1998), and more precisely with the question of the impact of language features on word recognition on the other hand (Sauval et al., 2018).

2.4. On the impact of language features.

In Experiment 2 of this thesis project, French students displayed no modality effect in L1, as is the case of Dutch people (Wolf et al., 2021). Moreover, frequent L1 words seems as easy to access in each modality in French, cross-modal repetition of those words not leading to a decrease of the activation threshold of their representations in the other modality (Experiment 4), while this type of effect was demonstrated in French as an L2 among English-French bilinguals. On the contrary, English students presented a modality effect in favour of the written modality in English (Experiment 2). This latter effect is probably related to the inconsistency of English language orthography, making it more difficult to recognize spoken words. Actually, it is important to note that French and Dutch languages have shallower orthography than English language, Dutch language orthography being even shallower than French one. Nevertheless, among the different European languages classified by Seymour et al. (2003), those three languages belong to the languages with the deepest orthography. Moreover, the syllabic structure seems not to be as crucial for word recognition, given that Dutch and English languages share a complex syllabic structure, whereas French language has a simple one (Seymour et al., 2003). Therefore, language features are able to affect word recognition, in L1 and in L2 (Lukatela & Turvey, 1994; Rastle & Brysbaert, 2006; Sauval et al., 2018). In L1 notably, even though those languages share the same alphabetic system, French, Dutch and English word recognitions depend on language features, especially on language orthographic depth (Seymour et al., 2003).

Furthermore, English-French bilinguals presented a modality effect in L2, in favour of the written one, seeming to be of larger amplitude (11 points) than that of French-English bilinguals (five points), even if a direct comparison was not possible (Experiment 1). Furthermore, French-English bilinguals presented a cognate effect, with five points higher accuracy scores for cognate words than non-cognate ones, whereas English-French bilinguals showed the same type of cognate effect, with a 27-point amplitude. This seems to indicate that English-French bilinguals used the between-language orthographic similarity more than French-English bilinguals, during L2 word recognition. Therefore, within-language orthographic consistency and between-language orthographic congruence are language features crucial to take into consideration. This is in line with previous studies, demonstrating that between-language orthographic incongruence is of major importance, given the co-activation of both (L1 and L2) conversion systems during word recognition (Commissaire et al., 2019).

Interestingly, the Multilink model (Dijkstra et al., 2019) is a computational model of bilingual word recognition. It proposed, within the same network architecture, both L1 and L2 word recognitions, which allow a cross-language lexical competition. Therefore, L1 background can influence L2 word recognition. Notably, the writing system corresponding to each language is of major interest, as demonstrated by Muljani et al., in 1998. They compared Chinese, Indonesian and English native-speaker performances on English lexical decision tasks. The different groups thus varied in their L1 background. English native-speakers were monolinguals. Indonesian bilinguals were L1 alphabetic bilinguals, using an alphabetic system in L1 and in L2. Finally, Chinese bilinguals were L1 logographic bilinguals, with different writing system in L1 and in L2. English word recognition was faster among monolinguals than alphabetic bilinguals, itself faster than among logographic bilinguals. The Multilink model would thus consider this possibility of an influence from one language over the other, although it did not take into account between-language orthographic incongruence or within-language orthographic inconsistency.

We propose to compute those parameters into a generalized model, in which language nodes would spread activation differently – *i.e.,* with a **different weight affected to each language as an L1 and to each language as an L2 –** depending on the incongruence of both language orthographies and on the inconsistency of each language orthography.

Finally, given the automatic activation of the phonological code during written word recognition, and of the orthographic code during spoken word recognition (Rastle & Brysbaert, 2006; Sauval et al., 2018; Veivo, 2017; Veivo et al., 2016), the question arises of the connections between orthographic and phonological lexical representations in L2.

8.5.1. On the links between L2 orthographic and phonological lexical representations.

Late bilinguals can learn L2 words *via* the oral modality, thanks to the exposure to the L2 through medias notably, as well as *via* the written modality, which is favoured in most of school didactic situations. However, late bilinguals being characterized by their literacy in L1, their L2 vocabulary learning is particularly sensitive to language features, especially the different OPM of each language. These OPM allow the access to the phonological form of a word when confronted with its orthographic form, and *vice-versa*. Given that most of L2 vocabulary learning is mediated by one modality only, either oral or written, it is therefore crucial to determine whether the access to a lexical unit inscribed into the mental lexicon of a bilingual through one modality can transfer to the other modality. In other words, it is particularly challenging and important to understand how words learned mostly in one modality – the written one for the current project – can create connections between their orthographic and phonological forms, allowing their recognition of their non-learned forms – the phonological one for the current project.

Critically, we highlighted the absence of session effect on L2 word recognition accuracy whatever the presence or not of cognate items into stimuli lists (Experiment 1). This lack of session effect corresponds to the absence of cross-modal repetition effect on L2 rare word recognition accuracy. It thus could be interpretated as a proof of the existence of orthographic and phonological lexical representations in L2 that are independent from each other among low-to-intermediate proficiency late bilinguals. This tends to indicate the absence of connections, or at least the existence of undeveloped connections, between both forms of words. Those connections, even if existing, are not robust enough for those rare words to allow a secondary more accurate recognition of words in a modality when presented firstly in the other modality.

Interestingly, Veivo and collaborators (2015) highlighted a modality effect on L3 translation accuracy, as described above. They pursued their investigation of this modality effect with a second experiment. In the latter, their participants (14 in each group) performed two translation tasks in French as an L3, one in each modality, with a counterbalanced order of the modalities. They replicated their finding concerning the modality effect on L3 translation accuracy. In addition, they analysed the impact of what they called “the test order”. They found no effect of the order of modalities. Therefore, translating a word in one modality did not help trilinguals to translate the same word in the other modality thereafter. This lack of effect – which corresponds to the session effect we defined in the experimental section – tends to indicate that L3 lexical representations are structured with orthographic and phonological representations in parallel, the orthographic ones being more robust than the phonological ones, which is entirely consistent with the absence of session effect in the first experiment of this thesis project.

Incidentally, Veivo et al. themselves hypothesized that their findings in French as an L3 among Finnish students would be generalisable to L2 learners, which seems to be effectively the case. Note that French language has a more inconsistent orthography than Finnish language, this one being one of the simplest European language (Seymour et al., 2003), and that English language has an even more inconsistent orthography than French language. Therefore, the hypothesis of Veivo et al. concerning the generalisability to L2 learners is verified, when the L2 has a more inconsistent orthography than the L1 as well as when those features are reversed – English-French bilinguals presenting also no session effect in French word recognition (Experiment 1).

Nevertheless, this interpretation could be supported as long as we only consider accuracy data. Indeed, the current project aimed to investigate further these connections, through the effect of cross-modal repetition on word recognition latencies. We outlined a session effect, with a pre-defined list of L2 frequent words eliciting shorter response latencies after a cross-modal repetition than without this repetition (Experiment 3). This indicates the existence of connections between orthographic and phonological lexical representations in L2 concerning words with higher lexical frequencies than those of previous experiments (see Experiment 1 and Veivo et al., 2015, with words from the same range of lexical frequencies). Thus, the robustness of those connections seems dependent on lexical frequencies, and thus on language exposure. Moreover, this session effect was demonstrated in both written and oral modalities, indicating the bi-directionality of those flows.

In summary, the creation of these connections seems dependent on lexical frequencies, and thus on language exposure, while their robustness seems to rely more on L2 Proficiency, given that proficiency increase reflects the improvement of phonological processing in L2. Interestingly, those connections were integrated into the Multilink model (Dijkstra et al., 2019), which implement the effect of L2 proficiency, lexical frequencies and language exposure into the resting level activation of each word node. The fact that lexical frequencies and L2 proficiency were taken into consideration through the same parameter of the model is consistent with the fact that orthographic repetition priming of L2 spoken words is dependent on L2 proficiency, which reflects the ability of late bilinguals to process written primes phonologically, and thus to pre-activate the phonological representation of an L2 word through the connection between its orthographic and phonological representations (Experiment 5).

We propose to integrate this finding into the new model, not only through the resting level activation as proposed in the Multilink model (Dijkstra et al., 2019), but also **into the formulae corresponding to the connections** between each representation.

Given the different parameters influencing L2 word recognition among typical-readers, and especially language features – and thus within-language orthographic inconsistency and between-language orthographic incongruence, the question arises as to the possibility to apply the existing models, or the new model adapted from this project, to dyslexic-reader late bilinguals, characterised notably by a phonological deficit, impairing reading through the phonological route.

3. Word recognition among dyslexic-reader late bilinguals.

Surprisingly, dyslexic-readers presented a similar modality effect in favour of the written modality on L2 word recognition accuracy, despite their written stimuli processing difficulties in L1 (Experiment 1). This seems not totally consistent with the dual-route cascaded model of “visual word recognition and reading aloud(2001) which accounts for the altered processing of reading in dyslexic-readers, compared to expert-readers (see Chapter 2; Coltheart et al., 2001). It helps to understand how the phonological deficit of dyslexic-readers results in an alteration of their ability to access phonological representations from written words (Law et al., 2017; Peterson & Pennington, 2015; Snowling, 1981). Their reading is therefore impaired through the phonological pathway during the learning of reading. Then, the establishment of the lexical pathway is compromised (Gangl et al., 2017). Their difficulties to learn correctly GPC rules explain their pattern of results on L1 word recognition experiments, limited to an alteration of L1 written word recognition. Given that French and English languages have incongruent OPM, which parameter needs to be taken into account for L2 word recognition in both modalities among typical-readers (see previous section), and thus also among dyslexic-readers.

Moreover, this modality effect in favour of the written one in L2 is incongruent with previous studies demonstrating a kind of transfer of the impairment from the L1 to the L2 in reading (Lindgrén & Laine, 2011a; Lyon et al., 2003; Palladino et al., 2013; van Setten et al., 2017). Nevertheless, the studies showing this transfer were conducted among adults suspected of dyslexia, or among children younger than the middle-schoolers involved in our experiments. Therefore, the middle-schoolers of our experiments would have had more time to find strategies to compensate their written language processing difficulties than the children of those other studies. Concerning adults, our participants were dyslexic-readers with a history of speech therapy and no (or at least low) current reading difficulties, while the study of Lindgrén and Laine (2011a) was conducted among adults suspected of dyslexia due to their current reading difficulties. In other words, both samples of Lindgrén and Laine (2011a) experiment and of Experiments 1 and 2 of the current project present different characteristics, notably concerning the compensatory strategies they could have implement.

The fact that both samples are qualitatively different is by the way consistent with the fact that dyslexic-readers displayed no modality effect on L1 word recognition accuracy (Experiment 2). Thus, everything happened as if they were typical-readers, no group effect being highlighted in L1 word recognition accuracy. This surprising finding, given the written stimuli processing difficulties of dyslexic-readers, is nonetheless congruent with previous findings demonstrating the importance of distinguishing vocabulary breadth and depth concerning dyslexic-readers. Actually, Cavalli et al. (2016) compared typical and dyslexic-reader university students, noticing that the obtainment of university degrees requires the ability to manage an intensive exposure to written materials, which seems not suitable for dyslexic-readers. They evaluated, among other skills, the vocabulary breadth (quantitative parameter corresponding to the number of words known in L1) and depth (qualitative parameter corresponding to the precision of the lexical representation) of those university students. They demonstrated that dyslexic-reader performances were similar to those of typical-readers regarding vocabulary breadth, while they obtained higher scores concerning vocabulary depth, without any correlation with print exposure. This finding was interpretated as a proof that the robustness of lexical representations plays a role in compensatory strategies implemented by dyslexic-reader university students.

This hypothesis could explain the absence of group effect observed on L1 word recognition accuracy in Experiment 2, given that we only focused on word recognition accuracy[123], and thus on the fact that words were known by the participants, which corresponds to vocabulary breadth more than depth. Therefore, because they found strategies to compensate their written stimuli processing difficulties in L1, they displayed similar L1 word recognition accuracy than typical-readers did. It is not clear which compensatory strategies are implemented by dyslexic-readers. However, one thing is certain: vocabulary is mostly acquired through written language exposure (Nagy & Herman, 1987). Dyslexic-readers confronted with written documents would be able to decode the encountered words and thus to recognize them later in written modality. Given their phonological deficit, it is nonetheless likely that their decoding of those words is imprecise. Therefore, their probability of recognizing this word later in oral modality may be even lower than that of recognizing it in written one. This would consist in a modality effect in favour of the written one. In order to avoid this modality effect, dyslexic-readers could implement a strategy based on the encoding of words in both modalities simultaneously, while one modality would be sufficient for typical-readers. However, this kind of compensatory strategy being cognitively consuming, it could explain why they manage to use it in L1 – allowing the absence of modality effect – while they are not able to transfer it in L2 – explaining the observed modality effect in favour of the written modality. Indeed, concerning L2 word recognition, it is unclear whether compensatory strategies could be transferred from the L1 to the L2, while most studies dealing with this issue demonstrated that

[123] and not on latencies, while this is generally this parameter which was mostly affected by a group effect in the literature.

L1 reading difficulties are also observed in L2 (Lindgrén & Laine, 2011a; Palladino et al., 2013; van Setten et al., 2017).

Furthermore, the distinction between vocabulary breadth and vocabulary depth among dyslexic-readers raises the question of the robustness of their connections between orthographic and phonological lexical representations. Indeed, if the hypothesis of Cavalli et al. (2016) was confirmed, it would mean that dyslexic-readers compensate for their difficulties by improving the quality of their lexical representations, compared to those of typical-readers. Note that the quality of a lexical representation[124] depends on the robustness of the connections between orthographic, phonological and semantic representations of the corresponding word, which allows the perception of them as a single whole (Perfetti, 2007, 2017; Perfetti & Hart, 2002). Therefore, we would observe more robust connections between orthographic and lexical representations among dyslexic-readers, compared to typical-readers. Critically, we did not observe any cross-modal repetition effect in L1 among dyslexic-readers (Experiment 4). Nevertheless, it should be noted that this experiment analysed cross-modal repetition effect at the level of the list. Thus, at this level, the access to L1 words does not depend on previous presentations of those words in the other modality. This is in line with the imprecise orthographic lexical representations among dyslexic-readers, in relation to their written stimuli processing difficulties (Lyon et al, 2003; Snowling, 1981). This is also congruent with the fact that their phonological lexical representations are linked with those imprecise orthographic representations (Veivo, 2017). In addition, those imprecise orthographic representations do not allow a benefit for secondary spoken word recognition, through a pre-activation of their associated phonological representations. However, there was no significant effect among

[124] We won't deal in this manuscript with the Lexical Quality Hypothesis which hypothesizes that reading comprehension skills depend on the quality of lexical representations. Indeed, comprehension is a lexical processing of a higher level of complexity than word recognition, on which this project focused.

typical-readers too, making it difficult to conclude from the absence of effect among dyslexic-readers.

Finally and interestingly, we did not observe any cross-modal repetition effect on L2 word recognition latencies among dyslexic-readers (Experiment 3). This result contradicts also the hypothesis of a compensatory strategy based on the quality of lexical representations, and thus on the robustness of the connections between orthographic and phonological lexical representations, in L2 as in L1. Nevertheless, it should be noted that this result concerned word recognition, which is not a processing allowing to clearly assess vocabulary depth.

Given the specificities of dyslexic-readers outlined above, the existing psycholinguistic models of bilingual word recognition seem not directly applicable to this particular population. In order to take into consideration the characteristics of dyslexic-readers, we propose to adapt the Multilink model, by **the addition of a component relative to L1 reading efficiency**, which would add a negative coefficient in the formulae corresponding notably to connections associated with grapheme-phoneme correspondences. Furthermore, a **negative coefficient** would also be **applied to** both **L1 orthographic lexical representation resting level activations** and the **connections with their associated phonological ones**. This would account for their difficulties in written stimuli processing in L1, related to their phonological deficit. Finally, to integrate the less sensitivity of dyslexic-readers to cross-modal repetition in L2, we propose an **inhibitory connection between the component related to L1 reading efficiency and the L2 language node**. This inhibitory connection would adjust the formulae corresponding to the connections between L2 orthographic and phonological lexical representations *via* a negative coefficient reducing cross-modal repetition effects.

Considering all the adaptations and adjustments proposed above, to adapt the Multilink model to both typical and dyslexic-reader late bilinguals, the next section will present the proposed adapted model.

4. Proposition of an adapted model of bilingual word recognition.

Figure 73 page 271 presents the architecture of the modified model we propose, adapted from the Multilink model (Dijkstra et al., 2019), and entitled: “Bilingual model of visual and auditive word recognition among typical and dyslexic-reader late bilinguals”.

First and foremost, it is essential to keep in mind that the adapted model we propose here is not implemented. We simply propose a sort of work in progress, which is expected to become a base for future research, which would be necessary to demonstrate its reliability and to determine precisely if and how the different adjustments mentioned could be integrated in the existing model. This proposition was designed to account for word recognition in both modalities, in a bilingual context, among the specific population of late French-English bilinguals, either typical and dyslexic-readers. It therefore would be important to also determine the extent to which it could be generalized – or would need other adjustments – to other language pairs, depending on their orthographic inconsistency and incongruence notably. It is also important to note that this model considers only word recognition, both monolingual and bilingual, and not word processing as in the Multilink model (Dijkstra et al., 2019). Therefore, we consciously omit the outputs, in order to focus on word recognition in both modalities.

We will not describe entirely the architecture of this adaptation of the Multilink model, this one being not technically validated. For the comprehension of the global architecture, we suggest to refer to the publication concerning the existing model (Dijkstra et al., 2019). We will here only explain the main adaptations we propose, in reference to the Multilink model., with

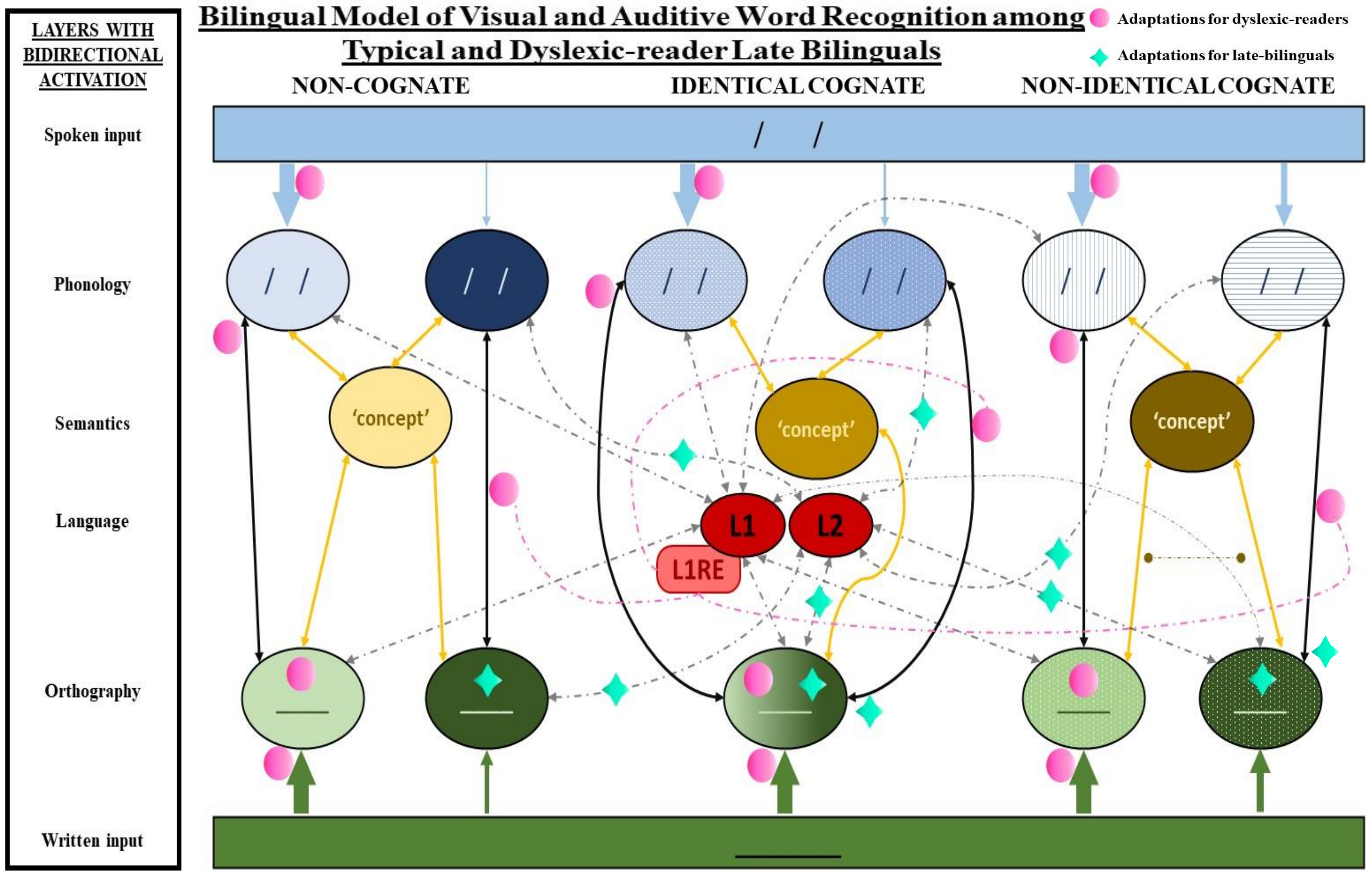

Figure 73. Proposition of a bilingual model of visual and auditive word recognition among typical and dyslexic-reader late bilinguals, adapted from the Multilink model (Dijkstra et al., 2019).

pink circles for those concerning dyslexic-readers, and blue turquoise stars for those concerning late bilinguals.

As the Multilink model, this new proposition was based on different layers, each corresponding to one kind of lexical representation – phonological, semantic or orthographic. We intentionally omitted the links between semantic representations (which correspond to the spreading of activation between associated semantic representations), as they were left unconsidered in the parent model, and because this is irrelevant for our purpose.

Firstly, we propose to integrate the possibility to process two type of inputs: either visual or auditive (respectively in green at the bottom and in blue at the top on Figure 73). Orthographic information is represented by underscores, and phonological one by slashes. Semantic representations are represented by yellow ellipses varying in the brightness of their colour, to allow their distinction. This basic architecture is proposed to consider both written and spoken word recognition, and therefore allow to account for the modality effect in L2 word recognition.

Secondly, we propose to integrate into the model lexicon based on the data of the APPREL-2 ANR project (for French-English late bilinguals), rather than that of monolingual databases, which would be less suitable for late bilinguals, mainly being unbalanced and having learned L2 vocabulary mostly though the written modality. Therefore, those more adapted data would be used for the calculation of the resting level activation of each L2 word node.

The Multilink model enables the simulation of cognate and non-cognate words processing. We propose thirdly to add the distinction between identical and non-identical cognate words. That is why we divided the schema into three main parts, devoted to non-cognate word recognition on the left, identical cognate word recognition in the middle, and non-identical cognate word recognition on the right.

Thus, if this is technically feasible to implement this distinction, the adapted model would simulate written and spoken recognition, in monolingual and bilingual contexts, of non-cognate, identical cognate and non-identical cognate words. This distinction would correspond to the fact that each type of word is associated differently with orthographic and phonological form in both languages (light colour for the L1 and dark colour for the L2 on the schema, for greater clarity). For example, a non-cognate word (left part) would be associated with one orthographic representation in each language, both connected with the same semantic representation, also linked with two phonological representations, one for each language. More, a non-identical cognate word (right part) would be associated with one orthographic representation in each language, takin into consideration the orthographic overlap between those translation equivalents (with white dots in both languages on the schema), both connected with the same semantic representation, also linked with two phonological representations, one for each language, that present a less important phonological overlap (with lines in both languages, but vertical in L1 and horizontal in L2). Finally, an identical cognate word (middle part) would be associated with only one orthographic form, identical for both L1 and L2 (light-to-dark green gradient on the schema), connected to a concept, and also to two different but relatively similar phonological forms, given the incongruence between L1 and L2 OPM (white dots varying in their spacing).

Fourthly, it would be interesting to integrate the language dominance characterizing late bilinguals, which are mostly unbalanced bilinguals. This could probably be incorporated in the resting level activation formulae, which already take into consideration L2 proficiency. Similarly, the modality effect in L2 word recognition would be noteworthy to integrate, notably through an adaptation of the resting level activation formulae, with different coefficient depending on the modality. In order to represent those adaptations on the schema, we decided to use the size of the arrows: the larger an arrow between an input and its representation is, the easier and faster the access to this representation would be.

Fifthly, we placed blue turquoise stars on each connection between the L2 language node and orthographic or phonological representations, to account for the need to adapt each of these connections, depending on L2 proficiency and its interaction with cross-language similarity, which would reflect that L2 proficiency increase is mainly related to an increase of L2 word recognition, mostly in oral modality. Likewise, in order to take into consideration that late bilinguals present a double-sided cognate effect, facilitatory in written modality, but proficiency-dependent in oral modality, the connections between orthographic and phonological representations of cognate words would need to be adapted. We represented this by blue turquoise stars on these connections for identical cognate words (to account that the connection from phonology to orthography is less facilitatory than that from orthography to phonology at the beginning of L2 learning, given the incongruence between L1 and L2 OPM; and to account for the progressive change with the increase of L2 proficiency, the connection from phonology to orthography becoming inhibitory, to avoid the interference of both languages) and for non-identical cognate words (with the same evolution, from a narrower amplitude).

Finally, the pink circles on the schema represent the adaptations proposed for dyslexic-readers. We suggested the integration of an L1RE component, related to L1 reading efficiency, which would manage the adaptations needed for dyslexic-readers, reflecting their phonological deficit and their written stimuli processing difficulties in L1, and to simulate their modality effect in favour of the written modality in L2 – while allowing to consider their difficulties to learn the new OPM associated with the L2.

Once again, further research is needed to determine if the adaptations proposed are technically feasible and if they represent the best way to account for the specificities of typical and dyslexic-reader late bilinguals.

Limitations of the project.

Firstly, the limited number of participants, notably in each group and sub-group of dyslexic-readers, linked with the difficulty to recruit them, is a major limitation of this project, explaining the need to replicate those findings.

Secondly, it is crucial to take into account that stimuli selections for each experiment was performed on the basis of a draft database of the APPREL-2 ANR project. Therefore, the various parameters taken into account for the selections and pairings would slightly differ in the final database (thanks to Ronald Peereman). Given that we highlighted the importance of those parameters, notably lexical frequencies, but also neighbourhoods for example, it would be necessary to further explore this impact of modality on L2 word recognition with other item selections based on the final database.

Thirdly, it was not possible to include some of the participants we planned to recruit, due to the COVID-19 pandemics and its consequences. Notably, dyslexic-reader and middle-schooler samples were smaller than expected, or even completely absent. However, their performances would be of major interest, necessitating further experiments.

Fourthly, given that language features were outlined to be a crucial parameter influencing L2 word recognition, it is important to keep in mind that this project focused on French and English languages, which are part of the most orthographically complex and inconsistent European languages. Therefore, the characteristics of those languages would have influenced the results, notably among dyslexic-readers.

Finally, the need to implement some experiments online, to recruit participants despite the pandemics, was responsible, at least partially, for our inability to analyse some of the collected data.

Perspectives.

This thesis work opens new perspectives for the fundamental research on L2 word recognition across modalities. Notably, considering the main results of our five experiments and the incongruence between French and English OPM, the question then arises as to the activation of L1 orthographic knowledge during L2 spoken word recognition. Indeed, our population of interest consisting in intermediate proficiency bilinguals, L1 orthographic knowledge would have an influence on L2 spoken word recognition, due to their easier access than L2 orthographic knowledge (themselves having an impact as demonstrated by Experiment 5).

Moreover, this work demonstrated the superiority of the written modality over the oral one, through different experimental protocols, and notably the cross-modal repetition priming paradigm. Nevertheless, we analysed those cross-modal repetition effects from written to oral modalities only. Further research would be interested to compare those results with those of an analysis of the written-to-written repetition effects with various SOA, in order to determine the extent to which phonological processing of written words impacts written word recognition. Indeed, previous experiments demonstrated pseudo-homophone priming effects on L2 word recognition, suggesting an activation of both L1 and L2 phonological representations during L2 written word recognition (see notably: Duyck, 2005). Therefore, a within-modal repetition effect, such as the written-to-written repetition effect suggested above to analyse, would reflects the impact of the phonological processing of L2 written primes through the comparison between short and long SOA. We hypothesize that dyslexic-readers would present a lower impact of the phonological processing given their phonological deficit.

Furthermore, those experiments highlighted the importance of the existence of different lexical databases, freely available for researchers, in order to allow them to select items for their experiments on the basis of relevant databases considering the purpose of their research. The APPREL-2 database will be of major interest for French researchers in the field of bilingualism. However, it would be necessary to create the same type of database for oral lexical frequencies.

In addition, Experiment 1 put into perspective the well-known cognate facilitation effect, demonstrating that, even if the literature is full of studies on this topic, research is far from being completed and all the parameters related to the recognition of these very particular words have not been mastered. Notably, it is important to keep in mind that the duality of the cognate effect was demonstrated in English language, which is the most orthographically complex and inconsistent European language (Seymour et al., 2003). Therefore, it seemed necessary to investigate the interaction between modality and cognate effects with other language pairs, in order to determine the extent to which the interference of cognate words in oral modality is linked with the particularities of English language (notably its orthographic inconsistency) and its orthographic incongruence with French language, and thus refers to an orthographic activation during spoken stimuli processing.

Besides, the fact that French-English late bilinguals presented a modality effect in L2 only, whereas English-French bilinguals displayed this modality effect in both L1 and L2, raises the issue of the typicality of English language. Therefore, further research is needed to distinguish if this modality effect is specific of English language, or rather of second language in general. In the latter hypothesis, it would be interesting to determine why English-French bilinguals therefore displayed this modality effect in L1. Are French-English bilinguals the "victims" of the combination of both a mechanism depending on second language in general and the specificity of English language itself? If so, bilinguals with other L1 learning English as an L2 would display consistent results. If not, it could be specific to the language pair itself. Therefore, the question finally arises of the generalizability of this modality effect to other languages.

Furthermore, it is interesting and surprising to note that: a) Experiment 1 highlighted a modality effect in favour of the written one in English as an L2 among French-English late bilinguals; b) Experiment 3 demonstrated a cross-modal repetition effect, at the level of the list, in both directions (from oral to written, as well as from written to oral modalities); and c) Experiment 5crevealed a cross-modal priming effect, from written to oral modalities, which amplitude depends on prime duration, and therefore on phonological processing of written primes. Indeed, this tends to indicate that French-English late bilinguals have robust links between orthographic and phonological lexical representations in L2, but that they are not able to use those links to improve their spoken word recognition. This sort of incongruence between the results of our experiments leads us to question the existence of a within written modality repetition priming effect.

Elsewhere, this modality effect on L2 word recognition accuracy was highlighted among late bilinguals having learned the L2 in an academic context, which is responsible for a bias in exposure in favour of the written modality. The question then arises as to the causal relation between the characteristics of the learning and this modality effect. Future research would focus on different learning method, notably depending on the presence or not of the orthographic information during the learning of new L2 word.

Finally, this work could be the basis of applied research, and would help language didacticians to understand how students, either dyslexic or typical-readers, performed L2 word recognition better.

Conclusion.

In conclusion, this project demonstrated that L2 lexical representations are modal-dependant. Moreover, it provided additional evidence for the existence of connections between orthographic and phonological lexical representations in English, which robustness depends on lexical frequencies, English proficiency and exposure, and L1 reading efficiency. Finally, this project demonstrated that the well-known cognate facilitation effect should be put into perspective. Indeed, even if it is clearly facilitating in written modality, it is a little less clear-cut in oral modality. Cognate words seem to hamper, or at least not accelerate, spoken word recognition.

The main findings of the various experiments are consistent with the Multilink model proposed recently by Dijkstra and collaborators (2019). Nevertheless, they also demonstrated the need to further explore the bilingual word recognition, notably taking into consideration some specificities of: a) items, such as cognate words, and in particular the difference between identical and non-identical cognate words; b) participants, such as L1 reading efficiency and L2 proficiency; and c) languages, such as orthographic inconsistency of each language, and the incongruence between both L1 and L2 orthography of each participant.

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APPENDICES

Appendix 1. The CATALISE consortium.

For many years, language disorders included different types of impairments, concerning both oral and written languages. It was assumed that children whose oral language development is different from the usual course, in total isolation (*i.e.*, despite a typical development of the other areas), present a specific language impairment (SLI – Aram et al., 1993; Aram et al., 1984; Tallal, 1988). The term "specific" was very important, because it implied the isolated impairment of the oral language sphere. It was the same for written language impairment, with developmental dyslexia corresponding to a specific reading/spelling impairment (Fletcher et al., 1994; Lyon et al., 2003). And this specificity explained the necessary exclusion of other disorders, as mentioned above.

Nevertheless, the term "specific" has gradually become controversial, due to its discrepancy with clinical realities and to the fact that it excluded many children from the diagnosis, despite the frequent co-occurrence of these impairments and some other conditions, such as autism spectrum disorder or attention deficit with/without hyperactivity disorder (Bishop, 2010). In addition, unexplained language impairments were relatively common among children, without a good agreement concerning the criteria of identification and classification of such problems. Consequently, a significant number of children were not identified and thus missed prevention and intervention services. In an effort to reach a consensus concerning criteria and terminology of significant language impairments, the CATALISE consortium was created, using an online version of the Delphi technique[125] (Bishop et al., 2016; Bishop et al., 2017).

[125] The Delphi technique is a prediction method, that assumes the principle that predictions made by a structured group of experts are more reliable than those of unstructured groups or individuals (Hasson et al., 2000).

The second phase of this consortium focused on the issue of terminology (Bishop et al., 2017). A consensus (with an agreement of 78% or more) was obtained for a huge number of statements. Critically, the three most relevant statements for this thesis project are the followings:

a.The first one is the statement 5: “Rather than using exclusionary criteria in the definition of language disorder, we draw a threefold distinction between differentiating conditions, risk factors and co-occurring conditions” (Bishop et al., 2017). This consensual statement assumes that exclusionary criteria were often misuse, interpretated as criteria for refusing to provide children’s aid services.

b.The second one is the statement 6: “Differentiating conditions are biomedical conditions in which language disorder occurs as part of a more complex pattern of impairments. […] We recommend referring to ‘Language disorder associated with X’, where X is the differentiating condition” (Bishop et al., 2017). All biomedical conditions with which a language disorder may co-occur are included in this statement, such as brain injury, epilepsy, neurodegenerative conditions, hearing-loss, Down syndrome, autism spectrum disorder, intellectual disability, … (Harris, 2013; Tomblin et al., 2015).

c.The third one is the statement 7: “The term Developmental Language Disorder (DLD) is proposed to refer to cases of language disorder with no known differentiating condition…” (Bishop et al., 2017). The term “Developmental Language Disorder” is consistent with the 11th revision of the International Classification of Diseases. Critically, the developmental aspect implies that the language disorder emerges in the course of development. The problem with the term “developmental” is its uselessness, and even its source of confusion, explaining its drop in adulthood (*e.g.,* developmental dyslexia is often called dyslexia when referring to adults, or even adolescents, as is the case in this thesis project).

Appendix 2. Child's Reading Habits and Book Availability Questionnaire

Bonjour,
Tu as accepté de participer au projet DYSANGL et nous t'en remercions.
Avant de pouvoir participer aux tests de ce projet, merci de bien vouloir répondre aux questions suivantes. Tu peux prendre le temps que tu veux pour répondre aux questions. Tes réponses seront automatiquement enregistrées lorsque tu passeras à la question suivante. Tu pourras compléter tes réponses ensuite si cela est nécessaire.
Merci de répondre à chacune des questions. Si tu ne connais pas les réponses à certaines questions, tu peux te faire aider d'un membre de ta famille.
Si tu as la moindre question, tu peux contacter la responsable du projet : Madame Camille Cornut (projetdysangl@gmail.com).

<u>Partie A : Scolarité.</u>

A1. Quel est ton nom ?
A2. Quel est ton prénom ?
A3. Indique ici tes mois et années de naissance (MM/AAAA) :
A4. Tu es : ☐ Une fille ☐ Un garçon

A5. Tu es : ☐ Droitier ☐ Gaucher
A6. En quelle classe es-tu ? ☐ Quatrième ☐ Troisième
A7. As-tu déjà redoublé une ou plusieur(s) classe(s) ? ☐ Oui ☐ Non
A8. Si oui, laquelle ou lesquelles ?
☐ Maternelles ☐ CE1 ☐ CM1 ☐ Sixième ☐ Quatrième
☐ CP ☐ CE2 ☐ CM2 ☐ Cinquième ☐ Troisième

<u>Partie B : Langage écrit et prise en charge.</u>

B1. As-tu eu un diagnostic de dyslexie ? ☐ Oui ☐ Non
B2. Si oui, en quelle classe étais-tu au moment de ce diagnostic ?
B3. Suite à ce diagnostic, as-tu bénéficié d'une prise en charge en orthophonie ?
☐ Oui ☐ Non
B4. Si oui, pendant combien de temps ?
☐ Moins d'un an ☐ De 1 à 2 ans ☐ De 2 à 4 ans ☐ Plus de 4 ans
B5. Bénéficies-tu encore d'une prise en charge en orthophonie ?
☐ Oui ☐ Non
B6. Cette prise en charge t'a-t-elle aidé ?
☐ Presque pas ☐ Un peu ☐ Beaucoup ☐ Enormément
B7. D'autres diagnostics que la dyslexie t'ont-ils été posés ?
☐ Dysorthographie ☐ Dysphasie ☐ Trouble de déficit d'attention avec/sans hyperactivité
☐ Dyscalculie ☐ Dyspraxie
☐ Autre :

B8. A ta connaissance (et celle de tes parents), des membres de ta famille ont-ils eu ou ont-ils encore des difficultés de lecture ?
☐ Parents
☐ Frères / Sœurs

- ☐ Oncles / Tantes
- ☐ Cousins / Cousines
- ☐ Grands-parents
- ☐ Autres :

Partie C : Habitudes de lecture.

C1. Sur une échelle de 1 à 5, évalue ton attitude vis-à-vis de l'école primaire. 1 correspond à « Tu détestais l'école (tentais d'éviter d'y aller) », 5 correspond à « Tu aimais l'école (activité favorite) ».

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

C2. Dans quelle mesure as-tu eu des difficultés pour apprendre à lire à l'école primaire ?

- ☐ Enormément de difficultés
- ☐ Beaucoup de difficultés
- ☐ Des difficultés
- ☐ Quelques difficultés
- ☐ Pas de difficulté

C3. As-tu eu besoin d'une aide extérieure pour apprendre à lire à l'école primaire ?Aide d'un Orthophoniste

- ☐ Aide d'un Enseignant spécialisé
- ☐ Aide des professeurs / parents
- ☐ Aide d'un ami
- ☐ Aucune aide

C4. Sur une échelle de 1 à 5, évalue ton niveau de lecture par rapport à tes camarades de classe. (1 correspond à « Inférieur à la moyenne », 3 correspond à « Dans la moyenne », 5 correspond à « Supérieur à la moyenne »).

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

C5. Comment lis-tu par rapport à tes camarades de classe ?

- ☐ Beaucoup plus lentement
- ☐ Plus lentement
- ☐ Légèrement plus lentement
- ☐ Dans la moyenne
- ☐ Plus rapidement

C6. Parmi les documents suivants, coche ceux que tu trouves intéressants à lire :

	Livres	Journaux	Magazines / Revues	Quotidiens de presse	Bandes dessinées	Romans	Recueil de poésies	Pièces de théâtre	Nouvelles	Pages web
Très intéressant										

Peu intéressant									

C7. Lis-tu le journal (presse écrite ou en ligne) tous les jours ?

- ☐ Oui
- ☐ Non

C8. Habituellement, lis-tu tous les jours ?

- ☐ Oui
- ☐ Non

C9. Parmi ces propositions, lesquelles considères-tu comme des raisons expliquant la nécessité de lire ?

	Oui	Non
Pour passer un examen		
Pour le plaisir		
Pour le développement personnel		
Pour passer le temps		
Pour être bien informé		

C10. As-tu la possibilité d'emprunter des livres au CDI de votre collège ?

- ☐ Oui
- ☐ Non

C11. Vas-tu parfois emprunter des livres dans une autre bibliothèque que le CDI de ton collège ?

☐ Oui ☐ Non

C12. Combien de temps passes-tu chaque jour à lire (leçons, smartphones, livres, …) ?

☐ Moins d'1h ☐ De 1 à 2h ☐ De 2 à 3h ☐ De 3 à 4h ☐ De 4 à 5h ☐ Plus de 5h

C13. Parmi ces propositions, quels sont les principaux facteurs qui t'empêchent de lire ?

- ☐ Faire du sport, des jeux de plein air
- ☐ Regarder la télévision
- ☐ Jouer aux jeux vidéos
- ☐ Sortir avec vos amis
- ☐ Avoir peu d'intérêt pour la littérature jeunesse
- ☐ Ne pas avoir de livre à disposition

Partie D : Expérience des langues.

D1. Liste ici toutes les langues (français, anglais, allemand, espagnol, arabe, autres, …) que tu connais, en les classant par ordre de maîtrise, de celle que tu maîtrises le mieux à celle que tu maîtrises le moins bien.

- ☐ 1 (la plus maîtrisée) :
- ☐ 2 :
- ☐ 3 :
- ☐ 4 :
- ☐ 5 :
- ☐ 6 :
- ☐ 7 :
- ☐ 8 :
- ☐ 9 :
- ☐ 10 :

D2. Liste ici toutes les langues (français, anglais, allemand, espagnol, arabe, autres, …) que tu connais, en les classant dans l'ordre dans lequel tu les as apprises.

- ☐ 1 (première langue apprise) :
- ☐ 2 :
- ☐ 3 :
- ☐ 4 :
- ☐ 5 :
- ☐ 6 :
- ☐ 7 :
- ☐ 8 :
- ☐ 9 :
- ☐ 10 :

D3. Tu es exposé au français :

- ☐ Tout le temps
- ☐ Tous les jours
- ☐ Une fois par semaine
- ☐ Une fois par mois
- ☐ Moins souvent

D4. Tu es exposé à l'anglais :

- ☐ Tout le temps
- ☐ Tous les jours
- ☐ Une fois par semaine
- ☐ Une fois par mois
- ☐ Moins souvent

D5. Indique ici à quelle fréquence tu écoutes de la musique dans ces différentes langues :

	Tous les jours	Une fois par semaine	Une fois par mois	Moins souvent
En français				
En anglais				
Autres				

D6. Indique ici à quelle fréquence tu lis dans ces différentes langues :

	Tous les jours	Une fois par semaine	Une fois par mois	Moins souvent
En français				
En anglais				
Autres				

D7. Indique ici à quelle fréquence tu regardes des vidéos dans ces différentes langues :

	Tous les jours	Une fois par semaine	Une fois par mois	Moins souvent
En français				
En anglais				
Autres				

D8. Indique ici à quelle fréquence tu joues à des jeux vidéo dans ces différentes langues :

	Tous les jours	Une fois par semaine	Une fois par mois	Moins souvent
En français				
En anglais				
Autres				

Partie E : Autres.

E1. Portes-tu des lunettes ou des lentilles ?
- ☐ Oui
- ☐ Non

E2. As-tu des difficultés auditives ?
- ☐ Oui
- ☐ Non

E3. Quel est le plus haut niveau d'étude atteint par ta mère ?

☐ Fin de Collège	☐ Bac +1	☐ Bac +3 (Licence)	☐ Bac +5 (Master)
☐ Baccalauréat	☐ Bac +2	☐ Bac +4 (Maîtrise)	☐ Niveau supérieur

E4. Quelle est la profession actuelle de ta mère ?

E5. Quel est le plus haut niveau d'étude atteint par ton père ?
- ☐ Fin de Collège
- ☐ Baccalauréat
- ☐ Bac +1
- ☐ Bac +2
- ☐ Bac +3 (Licence)
- ☐ Bac +4 (Maîtrise)
- ☐ Bac +5 (Master)
- ☐ Niveau supérieur

E6. Quelle est la profession actuelle de ton père ?

Merci de ta collaboration.
Si tu as la moindre question, tu peux contacter la responsable du projet : Madame Camille Cornut (projetdysangl@gmail.com).

Appendix 3. Adult Reading Habits Questionnaire

Bonjour,

Vous avez accepté de participer au projet DYSANGL et nous vous en remercions.
Avant de pouvoir réaliser les tests nécessaires à ce projet, merci de bien vouloir répondre aux questions suivantes.
Vous pouvez prendre le temps que vous voulez pour répondre aux questions. Vos réponses seront automatiquement enregistrées lorsque vous passerez à la question suivante. Vous pourrez compléter vos réponses ensuite si cela est nécessaire.
Merci de répondre à chacune des questions.
Si vous avez la moindre question, vous pouvez contacter la responsable du projet : Madame Camille Cornut (projetdysangl@gmail.com).

Partie A : Renseignements.

A1. Quel est votre nom ?
A2. Quel est votre prénom ?
A3. Quelle est votre année de naissance (AAAA) ?
A4. Vous êtes : ☐ Une femme ☐ Un homme
A5. Portez-vous des lunettes ou des lentilles ?
- ☐ Oui
- ☐ Non

A6. Avez-vous des difficultés auditives ?
- ☐ Oui
- ☐ Non

Partie B : Langage écrit et prise en charge.

B1. Avez-vous eu un diagnostic de dyslexie ? ☐ Oui ☐ Non
B2. Si oui, en quelle classe étiez-vous au moment de ce diagnostic ?
B3. Suite à ce diagnostic, avez-vous bénéficié d'une prise en charge en orthophonie ? ☐ Oui ☐ Non
B4. Si oui, pendant combien de temps ?
☐ Moins d'un an ☐ De 1 à 2 ans ☐ De 2 à 4 ans ☐ Plus de 4 ans
B5. Cette prise en charge vous a-t-elle aidé ?
☐ Presque pas ☐ Un peu ☐ Beaucoup ☐ Enormément
B6. D'autres diagnostics que la dyslexie vous ont-ils été posés ?
☐ Dysorthographie ☐ Dysphasie ☐ Trouble de déficit d'attention avec/sans hyperactivité
☐ Dyscalculie ☐ Dyspraxie
☐ Autre :
B7. A votre connaissance, des membres de votre famille ont-ils eu ou ont-ils encore des difficultés de lecture ?
☐ Parents ☐ Oncles / Tantes ☐ Grands-parents
☐ Frères / Sœurs ☐ Cousins / Cousines ☐ Autre :

Partie C : Scolarité.

C1. Quel est le diplôme le plus élevé que vous ayez obtenu ?
C2. Quelle est votre profession actuelle ?

C3. Avez-vous déjà redoublé une ou plusieur(s) classe(s)s ?
- ☐ Oui
- ☐ Non

C4. Si oui, laquelle ou lesquelles ?

☐ Maternelles	☐ CE2	☐ Sixième	☐ Troisième	☐ Terminale
☐ CP	☐ CM1	☐ Cinquième	☐ Seconde	☐ Autre
☐ CE1	☐ CM2	☐ Quatrième	☐ Première	

Partie D : Habitudes de lecture à l'école primaire.

D1. Sur une échelle de 1 à 5, évaluez votre attitude vis-à-vis de l'école primaire. 1 correspond à « Vous détestiez l'école (tentiez d'éviter d'y aller) », 5 correspond à « Vous aimiez l'école (activité favorite) ».

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D2. Dans quelle mesure avez-vous eu des difficultés pour apprendre à lire à l'école primaire ?

☐ Enormément de difficultés ☐ Des difficultés ☐ Pas de difficulté
☐ Beaucoup de difficultés ☐ Quelques difficultés

D3. Avez-vous eu besoin d'une aide extérieure pour apprendre à lire à l'école primaire ?

☐ Aide d'un Orthophoniste ☐ Aide des Professeurs / Parents ☐ Aucune aide
☐ Aide d'un Enseignant spécialisé ☐ Aide d'un Ami

D4. Sur une échelle de 1 à 5, évaluez votre niveau de lecture par rapport à vos camarades de classe de l'école primaire. (1 correspond à « Inférieur à la moyenne », 3 correspond à « Dans la moyenne », 5 correspond à « Supérieur à la moyenne »).

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D5. Comment lisiez-vous par rapport à vos camarades de classe de l'école primaire ?

☐ Beaucoup plus lentement ☐ Légèrement plus lentement ☐ Plus rapidement
☐ Plus lentement ☐ A la même vitesse

D6. Quand vous étiez à l'école primaire, aimiez-vous lire ?

☐ Vous détestiez / tentiez d'éviter ☐ Un peu ☐ Enormément (activité favorite)
☐ Vous n'aimiez pas ☐ Beaucoup

D7. Quand vous étiez à l'école primaire, combien de livres lisiez-vous pour le plaisir chaque année ?

☐ Aucun ☐ 1 à 2 ☐ 2 à 5 ☐ 6 à 10 ☐ Plus de 10

D8. Dans quelle mesure avez-vous eu des difficultés pour apprendre l'orthographe à l'école primaire ?

☐ Enormément de difficultés ☐ Des difficultés ☐ Pas de difficulté
☐ Beaucoup de difficultés ☐ Quelques difficultés

D9. Quand vous étiez enfant, aviez-vous tendance à inverser l'ordre des lettres ou des chiffres ? Evaluez cette tendance sur une échelle de 1 à 5 (1 correspond à « Vous inversiez beaucoup l'ordre des lettres ou des chiffres », 5 correspond à « Non, vous n'inversiez pas l'ordre des lettres ou des chiffres ».

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D10. Dans quelle mesure avez-vous eu des difficultés pour apprendre le nom des lettres et/ou des couleurs quand vous étiez enfant ?

- Enormément de difficultés
- Des difficultés
- Pas de difficulté
- Beaucoup de difficultés
- Quelques difficultés

D11. A l'école primaire, deviez-vous travailler plus que vos camarades de classe pour terminer votre travail ?

- Beaucoup plus
- Un peu plus
- Pas du tout
- Plus
- A peu près autant

Partie E : Habitudes de lecture actuelles.

E1. Actuellement, avez-vous encore des difficultés pour lire ?

- Enormément de difficultés
- Des difficultés
- Pas de difficulté
- Beaucoup de difficultés
- Quelques difficultés

E2. Comment quantifieriez-vous le temps que vous passez à lire pour vos études, votre formation ou votre travail ? Vous lisez de façon :

- Je ne lis presque jamais
- Occasionnelle
- Très régulière
- Très occasionnelle
- Régulière

E3. Combien de livres lisez-vous pour le plaisir chaque année ?

- Aucun
- 1 à 2
- 2 à 5
- 6 à 10
- Plus de 10

E4. Comment définiriez-vous votre vitesse de lecture par rapport à vos collègues ?

- Beaucoup plus lente
- Légèrement plus lente
- Plus rapide
- Plus lente
- Dans la moyenne

E5. Actuellement, avez-vous encore des difficultés pour écrire sans fautes d'orthographe ?

- Enormément de difficultés
- Des difficultés
- Pas de difficulté
- Beaucoup de difficultés
- Quelques difficultés

E6. Vous arrive-t-il régulièrement d'inverser l'ordre des lettres ou des chiffres lorsque vous lisez ? Evaluez cette tendance sur une échelle de 1 à 5 (1 correspond à « Vous inversez beaucoup l'ordre des lettres ou des chiffres », 5 correspond à « Non, vous n'inversez pas l'ordre des lettres ou des chiffres ».

- 1
- 2
- 3
- 4
- 5

E7. Eprouvez-vous des difficultés à vous rappeler le nom des personnes et des lieux ?

- Enormément de difficultés
- Des difficultés
- Pas de difficulté
- Beaucoup de difficultés
- Quelques difficultés

Partie F : Expérience des langues.

F1. Listez ici toutes les langues (français, anglais, allemand, espagnol, arabe, autres, …) que vous connaissez, en les classant par ordre de maîtrise, de celle que vous maîtrisez le mieux à celle que vous maîtrisez le moins bien.

- 1 (la plus maîtrisée) :
- 2 :
- 3 :
- 4 :
- 5 :

- ☐ 6 :
- ☐ 7 :
- ☐ 8 :
- ☐ 9 :
- ☐ 10 :

F2. Listez ici toutes les langues (français, anglais, allemand, espagnol, arabe, autres, …) que vous connaissez, en les classant dans l'ordre dans lequel vous les avez apprises.

- ☐ 1 (première langue apprise) :
- ☐ 2 :
- ☐ 3 :
- ☐ 4 :
- ☐ 5 :
- ☐ 6 :
- ☐ 7 :
- ☐ 8 :
- ☐ 9 :
- ☐ 10 :

F3. Vous êtes exposé au français :

- ☐ Tout le temps
- ☐ Une fois par semaine
- ☐ Moins souvent
- ☐ Tous les jours
- ☐ Une fois par mois

F4. Vous êtes exposé à l'anglais :

- ☐ Tout le temps
- ☐ Une fois par semaine
- ☐ Moins souvent
- ☐ Tous les jours
- ☐ Une fois par mois

F5. Indiquez ici à quelle fréquence vous écoutez de la musique dans ces différentes langues :

	Tous les jours	Une fois par semaine	Une fois par mois	Moins souvent
En français				
En anglais				
Autres				

F6. Indiquez ici à quelle fréquence vous lisez dans ces différentes langues :

	Tous les jours	Une fois par semaine	Une fois par mois	Moins souvent
En français				
En anglais				
Autres				

F7. Indiquez ici à quelle fréquence vous regardez des vidéos dans ces différentes langues :

	Tous les jours	Une fois par semaine	Une fois par mois	Moins souvent
En français				
En anglais				
Autres				

F8. Indiquez ici à quelle fréquence vous jouez à des jeux vidéo dans ces différentes langues :

	Tous les jours	Une fois par semaine	Une fois par mois	Moins souvent
En français				
En anglais				
Autres				

Partie G : Autres.

G1. Quel est le plus haut niveau d'étude atteint par votre mère ?

- Fin de Collège Bac +1 Bac +3 (Licence) Bac +5 (Master)
- Baccalauréat Bac +2 Bac +4 (Maîtrise) Niveau supérieur

G2. Quelle est la profession actuelle de votre mère ?

G3. Quel est le plus haut niveau d'étude atteint par votre père ?

- Fin de Collège Bac +1 Bac +3 (Licence) Bac +5 (Master)
- Baccalauréat Bac +2 Bac +4 (Maîtrise) Niveau supérieur

G4. Quelle est la profession actuelle de votre père ?

Merci de votre collaboration.

Si vous avez la moindre question, vous pouvez contacter la responsable du projet : Madame Camille Cornut (projetdysangl@gmail.com).

Appendix 4. Experiment 1 – French university student groups - Demographic data of the sub-groups.

A4.1. French typical-reader university students.

Appendix-Table 1 below presents the demographic data of both sub-groups of French typical-reader university students – namely Oral-Written-TypFrUniv (OWTFU) and Written-Oral-TypFrUniv (WOTFU), as well as the statistics comparing those sub-groups.

Appendix-Table 1. Demographic data - French typical-reader university students - Experiment 1.

Data	Mean (SD) WOTFU group	Mean (SD) OWTFU group	p-value
Age	24 (5)	24 (3)	.942
Gender (% of Female)	75	75	1.000
Laterality (% of Right-handed)	62.5	87.5	**.046**
Age of formal acquisition of English as an L2	11 (1)	11 (1)	.724
Socio-economic status	5.03 (1.14)	4.43 (1.89)	.252

A4.2. French university students, both typical and dyslexic-readers.

Appendix-Table 2 page 310 presents the demographic data of the sub-groups of French university students, both typical – namely Oral-Written-TypmatchFrUniv (OWTmFU) and Written-Oral-TypmatchFrUniv (WOTmFU) sub-groups – and dyslexic-readers – namely Oral-Written-DysFrUniv (OWDFU) and Written-Oral-DysFrUniv (WODFU) sub-groups, as well as the statistics comparing those sub-groups.

Appendix-Table 2. Demographic data - French university students, both typical and dyslexic-readers - Typeriment 1.

Data	**Mean (SD)** **WODFU sub-group**	**Mean (SD)** **OWDFU sub-group**	**p-value**	**Mean (SD)** **WOTmFU sub-group**	**Mean (SD)** **OWTmFU sub-group**	**p-value**
Age	22 (3)	21 (2)	ns	22 (2)	21 (2)	ns
Gender (% of Female)	100	50	ns	89	100	ns
Laterality (% of Right-handed)	89	100	ns	78	87.5	ns
Age of formal acquisition of English as an L2	12 (1)	11 (1)	ns	12 (0)	12 (1)	ns

Appendix 5. Experiment 1 – French university students – pairings between typical and dyslexic-readers.

Appendix-Table 3 below presents the pairings between French typical and dyslexic-reader university students of Experiment 1.

Appendix-Table 3. Pairings between typical and dyslexic-readers - French university students - Experiment 1.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Age	22 (2)	21 (2)	ns
Gender (% of Female)	76	94	ns
Laterality (% of Right-handed)	94	82	ns
Schooling level	2.59 (1.58)	2.35 (1.77)	ns
Socio-economic status	4.30 (2.13)	4.72 (2.17)	ns
Age of formal acquisition of English as an L2	11 (1)	12 (1)	ns
L2 Proficiency (DL out of 1,000)	580 (141)	591 (117)	ns
Order of presentation of modalities (% of WO)	53	53	ns

Appendix 6. Experiment 1 – French middle-school student groups - Demographic data of the sub-groups.

A6.1. French typical-reader middle-school students.

Appendix-Table 4 below presents the demographic data of both sub-groups of French typical-reader middle-school students – namely Oral-Written-TypFrMid (OWTFM) and Written-Oral-TypFrMid (WOTFM), as well as the statistics comparing those sub-groups.

Appendix-Table 4. Demographic data - French typical-reader middle-school students - Experiment 1.

Data	Mean (SD) WOTFM group	Mean (SD) OWTFM group	p-value
Age	15 (1)	15 (1)	ns
Gender (% of Female)	60	48	ns
Laterality (% of Right-handed)	80	87	ns
Age of formal acquisition of English as an L2	12 (1)	12 (0)	ns
Socio-economic status	5 (.79)	5 (.16)	ns

A6.2. French middle-school students, both typical and dyslexic-readers.

Appendix-Table 5 page 313 presents the demographic data of the sub-groups of French middle-school students, both typical – namely Oral-Written-TypmatchFrMid (OWTmFM) and Written-Oral-Typmatch-FrMid (WOTmFM) sub-groups – and dyslexic-readers – namely Oral-Written-DysFrMid (OWDFM) and Written-Oral-DysFrMid (WODFM) sub-groups, as well as the statistics comparing those sub-groups.

Appendix-Table 5. Demographic data - French middle-school students, both typical and dyslexic-readers - Experiment 1.

Data	**Mean (SD)** **WODFM subgroup**	**Mean (SD)** **OWDFM subgroup**	**p-value**	**Mean (SD)** **WOTmFM subgroup**	**Mean (SD)** **OWTmFM subgroup**	**p-value**
Age	15 (1)	15 (1)	ns	15 (1)	15 (1)	ns
Gender (% of Female)	37.5	56	ns	75	62.5	ns
Laterality (% of Right-handed)	100	78	ns	62.5	87.5	ns
Age of formal acquisition of English as an L2	12 (1)	11 (1)	ns	12 (1)	12 (0)	ns

Appendix 7. Experiment 1 – French middle-school students – pairings between typical and dyslexic-readers.

Appendix-Table 6 below presents the pairings between French typical and dyslexic-reader middle-school students of Experiment 1.

Appendix-Table 6. Pairings between typical and dyslexic-readers - French middle-school students - Experiment 1.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Age	15 (1)	15 (1)	ns
Gender (% of Female)	47	71	ns
Laterality (% of Right-handed)	88	77	ns
Schooling level	1.29 (.47)	1.29 (.47)	ns
Socio-economic status	3.07 (2.46)	3.58 (1.75)	ns
Age of formal acquisition of English as an L2	12 (0)	12 (1)	ns
L2 Proficiency (DL out of 1,000)	185 (155)	238 (127)	ns
Order of presentation of modalities (% of WO)	47	47	ns

Appendix 8. Experiment 1 – English university student sub-groups - Demographic data of the sub-groups.

Appendix-Table 7 below presents the demographic data of both sub-groups of English typical-reader university students – namely Oral-Written-TypEnUniv (OWTEU) and Written-Oral-TypEnUniv (WOTEU) sub-groups, as well as the statistics comparing those sub-groups.

Appendix-Table 7. Demographic data - English typical-reader university students - Experiment 1.

Data	Mean (SD) WOTEU sub-group	Mean (SD) OWTEU sub-group	p-value
Age	20 (3)	20 (4)	ns
Gender (% of Female)	80	79	ns
Laterality (% of Right-handed)	95	84	ns
Age of formal acquisition of French as an L2	11 (3)	10 (3)	ns
Socio-economic status	5 (2)	5 (2)	ns

Appendix 9. Experiment 1 – French university student groups – Complete analysis of answers of the sub-groups to the Adult Reading Habits Questionnaire.

A9.1. French typical-reader university students.

Appendix-Table 8 below presents the answers of both sub-groups of French typical-reader university students – namely Oral-Written-TypFrUniv (OWTFU) and Written-Oral-TypFrUniv (WOTFU) sub-groups, to the Adult Reading Habits Questionnaire, as well as the statistics comparing those sub-groups. Most of questions were asked on a five-point Likert scale: the higher the value of the answer, the higher the ability to read for example. Conversely, the question concerning frequencies were asked on a four-point Likert scale: the lower the value of the answer, the higher the frequency of behaviour.

Appendix-Table 8. Questionnaire - French typical-reader university students - Experiment 1.

Data	Mean (SD) WOTFU group	Mean (SD) OWTFU group	p-value
Attitude toward primary school	3.92 (.88)	4.08 (.88)	ns
Difficulties learning to read in primary school	4.71 (.62)	4.63 (.65)	ns
Help learning to read in primary school	4.67 (.76)	4.13 (1.30)	ns
Reading level, compared to peers, in primary school	4.17 (.87)	3.88 (.74)	ns
Reading speed, compared to peers, in primary school	4.33 (.48)	4.04 (.96)	ns
Judgment of reading activity in primary school	3.92 (.93)	3.71 (1.12)	ns
Number of books read per year for pleasure in primary school	3.75 (1.03)	3.46 (1.47)	ns
Difficulties learning orthography in primary school	4.33 (.92)	4.04 (1.08)	ns
Tendency to reverse letters or digits in primary school	4.42 (1.25)	4.46 (.83)	ns
Difficulties learning the names of people or places in primary school	4.92 (.28)	4.71 (.62)	ns
Amount of work to complete in primary school, compared to peers	4.29 (.62)	4.29 (.96)	ns
Actual difficulties to read	4.96 (.20)	4.92 (.28)	ns
Actual time spent to read per day	3.75 (1.23)	4.00 (1.06)	ns
Actual number of books read per year for pleasure	3.21 (1.14)	3.21 (1.06)	ns
Actual reading speed, compared to peers	3.92 (.65)	3.92 (.88)	ns
Actual difficulties in writing without spelling mistakes	4.63 (.71)	4.5 (.93)	ns
Actual tendency to reverse letters or digits	4.79 (.83)	4.46 (1.14)	ns
Actual difficulties in remembering names of people and places	4.33 (.64)	4.13 (1.08)	ns

Data	Mean (SD) WOTFU group	Mean (SD) OWTFU group	p-value
Exposure to French language	4.92 (.28)	4.96 (.20)	ns
Exposure to English language	3.33 (.87)	3.58 (.50)	ns
Frequency of listening to music in French language	1.42 (.78)	1.33 (.70)	ns
Frequency of listening to music in English language	1.25 (.44)	1.17 (.38)	ns
Frequency of listening to music in another language	3.71 (.69)	3.46 (.98)	ns
Frequency of reading in French language	1.08 (.41)	1.13 (.45)	ns
Frequency of reading in English language	2.00 (.98)	1.96 (1.08)	ns
Frequency of reading in another language	3.88 (.45)	3.75 (.74)	ns
Frequency of watching videos in French language	1.25 (.53)	1.04 (.20)	ns
Frequency of watching videos in English language	2.04 (.86)	1.92 (1.02)	ns
Frequency of watching videos in another language	3.83 (.64)	3.83 (.64)	ns
Frequency of playing video-games in French language	3.04 (1.20)	3.00 (1.29)	ns
Frequency of playing video-games in English language	3.25 (1.15)	3.17 (1.20)	ns
Frequency of playing video-games in another language	4.00 (.00)	4.00 (.00)	ns
Socio-economic status	5.03 (1.14)	3.98 (2.32)	ns

A9.2. French university students, both typical and dyslexic-readers.

Appendix-Table 9 below presents the answers of both typical and dyslexic-readers to the Adult Reading Habits Questionnaire, as well as the statistics comparing those groups.

Appendix-Table 9. Questionnaire - French university students: comparison between typical and dyslexic-readers - Experiment 1.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Dyslexic-readers	p-value
Attitude toward primary school	3.41 (.94)	3.71 (.92)	ns
Difficulties learning to read in primary school	2.53 (1.23)	4.47 (.72)	<.001
Help learning to read in primary school	2.77 (1.39)	4.18 (1.24)	<.01
Reading level, compared to peers, in primary school	1.82 (.73)	3.88 (.93)	<.001
Reading speed, compared to peers, in primary school	1.65 (.61)	3.88 (1.05)	<.001
Judgment of reading activity in primary school	1.82 (1.19)	3.59 (1.12)	<.001
Number of books read per year for pleasure in primary school	1.82 (1.02)	3.29 (1.36)	<.001
Difficulties learning orthography in primary school	1.71 (.92)	4.24 (.83)	<.001
Tendency to reverse letters or digits in primary school	2.77 (1.52)	4.47 (.72)	<.01
Difficulties learning the names of people or places in primary school	3.94 (1.03)	4.59 (.71)	ns
Amount of work to complete in primary school, compared to peers	2.29 (1.21)	3.88 (.78)	<.001
Actual difficulties to read	3.77 (.75)	4.94 (.24)	<.001
Actual time spent to read per day	4.12 (.86)	3.41 (1.37)	<.05
Actual number of books read per year for pleasure	3.29 (1.21)	3.12 (1.11)	ns
Actual reading speed, compared to peers	2.65 (1.06)	3.82 (.81)	<.01
Actual difficulties in writing without spelling mistakes	2.71 (1.05)	4.59 (.80)	<.001
Actual tendency to reverse letters or digits	3.41 (1.46)	4.65 (1.00)	<.05
Actual difficulties in remembering names of people and places	3.00 (1.28)	4.18 (.73)	<.01

Data	Mean (SD) Dyslexic-readers	Mean (SD) Dyslexic-readers	p-value
Exposure to French language	5.00 (.00)	4.94 (.24)	ns
Exposure to English language	3.35 (1.12)	3.29 (.77)	ns
Frequency of listening to music in French language	1.24 (.44)	1.53 (.88)	ns
Frequency of listening to music in English language	1.29 (.59)	1.18 (.39)	ns
Frequency of listening to music in another language	2.94 (1.20)	3.65 (.79)	ns
Frequency of reading in French language	1.18 (.73)	1.18 (.53)	ns
Frequency of reading in English language	2.35 (1.00)	2.18 (1.02)	ns
Frequency of reading in another language	3.77 (.75)	3.77 (.75)	ns
Frequency of watching videos in French language	1.06 (.24)	1.18 (.53)	ns
Frequency of watching videos in English language	1.65 (.70)	2.06 (.90)	<.05
Frequency of watching videos in another language	3.59 (.94)	3.77 (.75)	ns
Frequency of playing video-games in French language	2.77 (1.25)	3.47 (.88)	ns
Frequency of playing video-games in English language	3.24 (1.15)	3.47 (.88)	ns
Frequency of playing video-games in another language	4.00 (.00)	4.00 (.00)	ns
Socio-economic status	4.30 (2.13)	4.72 (2.17)	ns

A9.3. French university students, both typical and dyslexic-readers: comparison of sub-groups.

Appendix-Table 10 page 319 presents the answers of both sub-groups of typical (namely Oral-Written-TypmatchFrUniv (OWTmFU) and Written-Oral-TypmatchFrUniv (WOTmFU) sub-groups) and dyslexic-readers (namely Oral-Written-DysFrUniv (OWDFU) and Written-Oral-DysFrUniv (WODFU) sub-groups) to the Adult Reading Habits Questionnaire, as well as the statistics comparing those sub-groups.

Appendix-Table 10. Questionnaire - French university students: comparison of the subgroups of typical and dyslexic-readers - Experiment 1.

Data	Mean (SD) OWTmFU group	Mean (SD) WOTmFU group	p-value	Mean (SD) OWDFU group	Mean (SD) WODFU group	p-value
Attitude toward primary school	3.50 (1.07)	3.89 (.78)	ns	3.25 (1.28)	3.56 (.53)	ns
Difficulties learning to read in primary school	4.25 (.71)	4.67 (.71)	ns	2.38 (1.30)	2.67 (1.23)	ns
Help learning to read in primary school	3.75 (1.49)	4.56 (.88)	ns	2.50 (1.41)	3.00 (1.41)	ns
Reading level, compared to peers, in primary school	3.63 (1.06)	4.11 (.78)	ns	1.75 (.89)	1.89 (.60)	ns
Reading speed, compared to peers, in primary school	3.50 (1.41)	4.22 (.44)	ns	1.63 (.74)	1.67 (.50)	ns
Judgment of reading activity in primary school	3.38 (1.41)	3.78 (.83)	ns	1.50 (.76)	2.11 (1.45)	ns
Number of books read per year for pleasure in primary school	3.13 (1.73)	3.44 (1.01)	ns	1.75 (.89)	1.89 (1.17)	ns
Difficulties learning orthography in primary school	4.00 (1.07)	4.44 (.53)	ns	2.13 (1.13)	1.33 (.50)	ns
Tendency to reverse letters or digits in primary school	4.13 (.84)	4.78 (.44)	ns	2.75 (1.49)	2.78 (1.64)	ns
Difficulties learning the names of people or places in primary school	4.25 (.89)	4.89 (.33)	ns	3.88 (.99)	4.00 (1.12)	ns
Amount of work to complete in primary school, compared to peers	3.75 (1.04)	4.00 (.50)	ns	2.13 (1.36)	2.44 (1.13)	ns
Actual difficulties to read	4.88 (.35)	5.00 (.00)	ns	3.50 (.76)	4.00 (.71)	ns
Actual time spent to read per day	3.25 (1.28)	3.56 (1.51)	ns	3.63 (.92)	4.56 (.53)	<.05
Actual number of books read per year for pleasure	2.63 (.92)	3.56 (1.13)	ns	2.88 (1.25)	3.67 (1.12)	ns
Actual reading speed, compared to peers	3.63 (1.19)	4.00 (.00)	ns	2.38 (1.06)	2.89 (1.05)	ns
Actual difficulties in writing without spelling mistakes	4.38 (1.06)	4.78 (.44)	ns	2.50 (1.20)	2.89 (.93)	ns
Actual tendency to reverse letters or digits	4.38 (1.41)	4.89 (.33)	ns	3.88 (1.36)	3.00 (1.50)	ns
Actual difficulties in remembering names of people and places	4.13 (.84)	4.22 (.67)	ns	2.25 (1.04)	3.67 (1.12)	<.05

Data	Mean (SD) OWTmFU group	Mean (SD) WOTmFU group	p-value	Mean (SD) OWDFU group	Mean (SD) WODFU group	p-value
Exposure to French language	4.88 (.35)	5.00 (.00)	ns	5.00 (.00)	5.00 (.00)	ns
Exposure to English language	3.25 (.46)	3.33 (1.00)	ns	3.38 (1.19)	3.33 (1.12)	ns
Frequency of listening to music in French language	1.50 (1.07)	1.56 (.73)	ns	1.13 (.35)	1.33 (.50)	ns
Frequency of listening to music in English language	1.00 (.00)	1.33 (.50)	ns	1.38 (.74)	1.22 (.44)	ns
Frequency of listening to music in another language	3.50 (1.07)	3.78 (.44)	ns	2.88 (1.13)	3.00 (1.32)	ns
Frequency of reading in French language	1.38 (.74)	1.00 (.00)	ns	1.38 (1.06)	1.00 (.00)	ns
Frequency of reading in English language	2.50 (1.07)	1.89 (.93)	ns	2.38 (1.06)	2.33 (1.00)	ns
Frequency of reading in another language	3.50 (1.07)	4.00 (.00)	ns	3.50 (1.07)	4.00 (.00)	ns
Frequency of watching videos in French language	1.00 (.00)	1.33 (.71)	ns	1.00 (.00)	1.11 (.33)	ns
Frequency of watching videos in English language	2.25 (1.17)	1.89 (.60)	ns	1.88 (.83)	1.44 (.53)	ns
Frequency of watching videos in another language	3.63 (1.06)	3.89 (.33)	ns	3.38 (1.19)	3.78 (.67)	ns
Frequency of playing video-games in French language	3.75 (.46)	3.22 (1.09)	ns	2.63 (1.51)	2.89 (1.05)	ns
Frequency of playing video-games in English language	3.75 (.46)	3.22 (1.09)	ns	2.75 (1.39)	3.67 (.71)	ns
Frequency of playing video-games in another language	4.00 (.00)	4.00 (.00)	ns	4.00 (.00)	4.00 (.00)	ns
Socio-economic status	4.81 (1.62)	5.42 (2.03)	ns	4.20 (.72)	4.39 (1.81)	ns

Appendix 10. Experiment 1 – French middle-school student groups – Complete analysis of answers of the sub-groups to the Child’s Reading Habits and Book Availability Questionnaire.

A10.1. French typical-reader middle-school students.

Appendix-Table 11 below presents the answers of both sub-groups of French typical-reader middle-school students – namely Oral-Written-TypFrMid (OWTFM) and Written-Oral-TypFrMid (WOTFM), to the Child’s Reading Habits and Book Availability Questionnaire, as well as the statistics comparing those sub-groups. The same scales than for the Adult Reading Habits Questionnaire were used (see Appendix 9 page 316).

Appendix-Table 11. Questionnaire - French typical-reader middle-school students - Experiment 1.

Data	Mean (SD) WOTFU group	Mean (SD) OWTFU group	p-value
Attitude toward primary school	3.72 (.89)	3.52 (.67)	ns
Difficulties learning to read in primary school	4.24 (.66)	4.17 (.83)	ns
Help learning to read in primary school	4.15 (1.26)	4.13 (1.46)	ns
Reading level, compared to peers, in primary school	3.48 (.71)	3.65 (.65)	ns
Reading speed, compared to peers, in primary school	3.88 (.44)	4.00 (.52)	ns
Actual time spent to read per day	3.24 (1.59)	3.30 (1.43)	ns
Exposure to French language	4.92 (.28)	4.87 (.34)	ns
Exposure to English language	3.44 (.92)	3.44 (.51)	ns
Frequency of listening to music in French language	1.68 (.99)	1.52 (.99)	ns
Frequency of listening to music in English language	1.36 (.76)	1.44 (.90)	ns
Frequency of listening to music in another language	3.24 (1.20)	3.48 (.99)	ns
Frequency of reading in French language	1.12 (.33)	1.26 (.62)	ns
Frequency of reading in English language	2.16 (1.07)	2.26 (1.01)	ns
Frequency of reading in another language	3.40 (.91)	3.78 (.67)	ns
Frequency of watching videos in French language	1.12 (.60)	1.09 (.42)	ns
Frequency of watching videos in English language	2.04 (1.24)	2.09 (1.04)	ns
Frequency of watching videos in another language	3.64 (.86)	3.61 (.84)	ns
Frequency of playing video-games in French language	1.92 (1.26)	1.57 (.99)	ns
Frequency of playing video-games in English language	2.44 (1.36)	2.04 (1.22)	ns
Frequency of playing video-games in another language	3.80 (.58)	3.91 (.42)	ns
Socio-economic status	5.00 (.79)	5.00 (.16)	ns

A10.2. French middle-school students, both typical and dyslexic-readers.

Appendix-Table 12 below presents the answers of both typical and dyslexic-readers to the Child's Reading Habits and Book Availability Questionnaire, as well as the statistics comparing those groups.

Appendix-Table 12. Questionnaire - French middle-school students: comparison between typical and dyslexic-readers - Experiment 1.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Attitude toward primary school	3.29 (1.26)	3.59 (.71)	ns
Difficulties learning to read in primary school	2.77 (.97)	4.06 (.75)	<.001
Help learning to read in primary school	2.33 (1.32)	4.19 (1.19)	<.001
Reading level, compared to peers, in primary school	2.65 (.86)	3.59 (.71)	<.001
Reading speed, compared to peers, in primary school	2.88 (1.22)	3.88 (.49)	<.01
Actual time spent to read per day	3.71 (1.83)	3.06 (1.68)	ns
Exposure to French language	5.00 (.00)	5.00 (.00)	ns
Exposure to English language	2.94 (1.14)	3.41 (.80)	ns
Frequency of listening to music in French language	1.88 (1.41)	1.47 (.80)	ns
Frequency of listening to music in English language	1.88 (1.27)	1.71 (1.05)	ns
Frequency of listening to music in another language	3.00 (1.32)	3.35 (1.12)	ns
Frequency of reading in French language	1.59 (1.00)	1.18 (.53)	<.05
Frequency of reading in English language	2.88 (1.05)	2.53 (1.01)	ns
Frequency of reading in another language	3.82 (.53)	3.29 (1.16)	ns
Frequency of watching videos in French language	1.18 (.73)	1.12 (.49)	ns
Frequency of watching videos in English language	2.53 (1.12)	2.35 (1.27)	ns
Frequency of watching videos in another language	3.35 (1.06)	3.35 (1.06)	ns
Frequency of playing video-games in French language	1.71 (1.11)	2.06 (1.30)	ns
Frequency of playing video-games in English language	2.65 (1.27)	2.41 (1.33)	ns
Frequency of playing video-games in another language	3.71 (.59)	4.00 (.00)	<.05
Socio-economic status	3.33 (2.41)	3.77 (1.79)	ns

A10.3. French middle-school students, both typical and dyslexic-readers: comparison of sub-groups.

Appendix-Table 13 page 323 presents the answers of both sub-groups of typical (namely Oral-Written-TypmatchFrMid (OWTmFM) and Written-Oral-TypmatchFrMid (WOTmFM) sub-groups) and dyslexic-readers (namely Oral-Written-DysFrMid (OWDFM) and Written-Oral-DysFrMid (WODFM) sub-groups) to the Child's Reading Habits and Book Availability Questionnaire, as well as the statistics comparing those sub-groups.

Appendix-Table 13. Questionnaire - French middle-school students: comparison of the sub-groups of typical and dyslexic-readers - Experiment 1.

Data	Mean (SD) OWTmFM group	Mean (SD) WOTmFM group	p-value	Mean (SD) OWDFM group	Mean (SD) WODFM group	p-value
Attitude toward primary school	3.33 (.50)	3.88 (.84)	ns	3.11 (1.17)	3.50 (1.41)	ns
Difficulties learning to read in primary school	4.22 (.83)	3.88 (.64)	ns	2.56 (.88)	3.00 (1.07)	ns
Help learning to read in primary school	4.56 (.88)	3.79 (1.41)	ns	1.89 (.88)	2.90 (1.62)	ns
Reading level, compared to peers, in primary school	3.78 (.67)	3.38 (.74)	ns	2.56 (1.01)	2.75 (.71)	ns
Reading speed, compared to peers, in primary school	4.00 (.50)	3.75 (.46)	ns	2.56 (1.13)	3.25 (1.28)	ns
Actual time spent to read per day	2.56 (1.24)	3.63 (2.00)	ns	4.33 (1.66)	3.00 (1.85)	ns
Exposure to French language	5.00 (.00)	5.00 (.00)	ns	5.00 (.00)	5.00 (.00)	ns
Exposure to English language	3.44 (.53)	3.38 (1.06)	ns	2.67 (1.00)	3.25 (1.28)	ns
Frequency of listening to music in French language	1.22 (.67)	1.75 (.89)	ns	1.00 (.00)	2.88 (1.55)	<.01
Frequency of listening to music in English language	2.00 (1.23)	1.38 (.74)	ns	1.89 (1.27)	1.88 (1.36)	ns
Frequency of listening to music in another language	3.89 (.33)	2.75 (1.39)	<.05	3.00 (1.50)	3.00 (1.20)	ns
Frequency of reading in French language	1.33 (.71)	1.00 (.00)	ns	1.22 (.44)	2.00 (1.31)	ns
Frequency of reading in English language	2.44 (1.01)	2.63 (1.06)	ns	2.67 (1.12)	3.13 (.99)	ns
Frequency of reading in another language	3.67 (1.00)	2.88 (1.25)	ns	3.78 (.67)	3.88 (.35)	ns
Frequency of watching videos in French language	1.22 (.67)	1.00 (.00)	ns	1.00 (.00)	1.38 (1.06)	ns
Frequency of watching videos in English language	2.56 (1.24)	2.13 (1.36)	ns	2.33 (.87)	2.75 (1.39)	ns
Frequency of watching videos in another language	3.78 (.67)	2.88 (1.25)	ns	3.11 (1.27)	3.63 (.74)	ns
Frequency of playing video-games in French language	1.78 (1.09)	2.38 (1.51)	ns	2.00 (1.32)	1.38 (.74)	ns
Frequency of playing video-games in English language	2.22 (1.20)	2.63 (1.51)	ns	2.67 (1.32)	2.63 (1.30)	ns
Frequency of playing video-games in another language	4.00 (.00)	4.00 (.00)	ns	3.78 (.44)	3.63 (.74)	ns
Socio-economic status	3.81 (2.02)	4.68 (1.64)	ns	3.27 (2.45)	3.40 (2.42)	ns

Appendix 11. Experiment 1 – English typical-reader university student group – Complete analysis of answers of the sub-groups to the translated version of the Adult Reading Habits Questionnaire.

Appendix-Table 14 below presents the answers of both sub-groups of English typical-reader university students – namely Oral-Written-TypEnUniv (OWTEU) and Written-Oral-TypEnUniv (WOTEU), to the translated version of the Adult Reading Habits Questionnaire, as well as the statistics comparing those sub-groups. Most of questions were asked on a five-point Likert scale: the higher the value of the answer, the higher the ability to read for example. Conversely, the question concerning frequencies were asked on a four-point Likert scale: the lower the value of the answer, the higher the frequency of behaviour.

Appendix-Table 14. Questionnaire - English typical-reader university students - Experiment 1.

Data	Mean (SD) WOTEU group	Mean (SD) OWTEU group	p-value
Attitude toward primary school	4.40 (.50)	4.47 (.96)	ns
Difficulties learning to read in primary school	2.90 (.31)	2.79 (.54)	ns
Help learning to read in primary school	4.30 (1.17)	4.42 (1.02)	ns
Reading level, compared to peers, in primary school	4.25 (.72)	3.95 (.78)	ns
Reading speed, compared to peers, in primary school	3.30 (.57)	3.16 (.90)	ns
Judgment of reading activity in primary school	4.00 (.86)	3.79 (.92)	ns
Number of books read per year for pleasure in primary school	4.25 (.79)	4.05 (.85)	ns
Difficulties learning orthography in primary school	2.70 (.47)	2.79 (.42)	ns
Tendency to reverse letters or digits in primary school	4.05 (1.28)	3.95 (1.43)	ns
Difficulties learning the names of people or places in primary school	2.95 (.22)	3.00 (.00)	ns
Amount of work to complete in primary school, compared to peers	3.15 (.81)	3.26 (.65)	ns
Actual difficulties to read	2.95 (.22)	2.95 (.23)	ns
Actual time spent to read per day	4.00 (.80)	3.68 (1.00)	ns
Actual number of books read per year for pleasure	3.10 (1.07)	2.90 (1.24)	ns
Actual reading speed, compared to peers	3.00 (.65)	2.90 (.66)	ns
Actual difficulties in writing without spelling mistakes	2.65 (.49)	2.79 (.42)	ns
Actual tendency to reverse letters or digits	4.30 (1.34)	4.21 (1.32)	ns
Actual difficulties in remembering names of people and places	2.75 (.44)	2.68 (.58)	ns

Data	Mean (SD) WOTEU group	Mean (SD) OWTEU group	p-value
Exposure to French language	1.05 (.22)	1.11 (.32)	ns
Exposure to English language	4.00 (1.12)	3.95 (1.03)	ns
Frequency of listening to music in French language	1.00 (.00)	1.00 (.00)	ns
Frequency of listening to music in English language	3.25 (.85)	3.37 (.90)	ns
Frequency of listening to music in another language	2.75 (1.07)	2.83 (1.25)	ns
Frequency of reading in French language	1.00 (.00)	1.06 (.24)	ns
Frequency of reading in English language	3.30 (.80)	3.50 (.71)	ns
Frequency of reading in another language	3.30 (1.17)	3.47 (.94)	ns
Frequency of watching videos in French language	1.00 (.00)	1.06 (.24)	ns
Frequency of watching videos in English language	3.50 (.69)	3.67 (.69)	ns
Frequency of watching videos in another language	3.30 (1.08)	3.24 (1.09)	ns
Frequency of playing video-games in French language	2.55 (1.23)	2.33 (1.33)	ns
Frequency of playing video-games in English language	4.00 (.00)	3.89 (.47)	ns
Frequency of playing video-games in another language	3.95 (.22)	3.94 (.24)	ns
Socio-economic status	4.60 (2.15)	4.68 (2.06)	ns

Appendix 12. Experiment 1 – French typical-reader university student group – Complete results of the background tests.

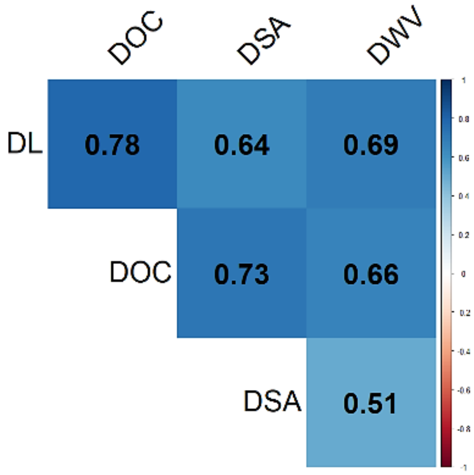
A12.1. Results of the subtests of the Dialang placement test.

Appendix-Table 15 below presents the results of both sub-groups of French typical-reader university students – namely Oral-Written-TypFrUniv (OWTFU) and Written-Oral-TypFrUniv (WOTFU), to the different subtests of the Dialang test, as well as the statistics comparing those sub-groups. The different subtests are the following: self-assessment (DSA), first level assessment (DL), oral comprehension test (DOC) and written vocabulary test (DWV).

Appendix-Table 15. Dialang test results - French typical-reader university students - Experiment 1.

Data	Mean (SD) WOTFU group	Mean (SD) OWTFU group	p-value
DSA: A1	0	1	
A2	0	0	
B1	9	8	ns
B2	9	8	
C1	6	7	
DL (out of 1,000)	669.33 (168.10)	688.67 (156.06)	ns
DOC: A1	3	5	
A2	10	4	
B1	4	2	ns
B2	5	7	
C1	2	6	
DWV: A1	0	1	
A2	3	2	
B1	6	3	ns
B2	13	15	
C1	2	3	

All those subtests are highly correlated with each other, as displayed in Appendix-Figure 1 page 327.



Appendix-Figure 1. Correlation matrix between subsets of Dialang placement test - French typical-reader university students - Experiment 1.

A12.2. Results of the other background tests.

Appendix-Table 16. Results of reading-related and neuropsychological tests - French typical-reader university students - Experiment 1.

Data	Mean (SD) WOTFU group	Mean (SD) OWTFU group	p-value
Subtests from the ECLA16+ battery			
« Alouette » Reading time (in sec.)	89.07 (11.28)	86.50 (12.38)	ns
« Alouette » number of words correctly read (out of 265)	260.83 (2.79)	261.04 (4.14)	ns
« Alouette » CTL score (Cavalli et al., 2018)	534.61 (62.38)	556.36 (97.77)	ns
« Pollueur » number of words correctly read in 1 min (out of 296)	194.33 (21.92)	199.92 (30.17)	ns
Word dictation score (out of 20)	16.29 (2.31)	16.21 (3.66)	ns
Word dictation time (in sec.)	85.12 (14.23)	81.87 (12.90)	ns
Pseudoword dictation score (out of 10)	8.50 (1.14)	8.38 (1.17)	ns
Pseudoword dictation time (in sec.)	46.93 (4.99)	46.73 (7.50)	ns
Initial phoneme deletion score (out of 10)	7.83 (2.85)	8.38 (2.50)	ns
Spoonerism score (out of 20)	17.63 (3.32)	18.79 (1.59)	ns
Symbol barrage score	24.21 (5.06)	22.50 (6.92)	ns
Picture naming time (in sec.)	13.64 (1.57)	14.69 (3.34)	ns
Letter naming time (in sec.)	15.62 (2.09)	15.65 (3.36)	ns
Subtests from the EVALEC battery			
Number of pseudowords correctly read (out of 36)	33.25 (2.09)	33.21 (2.84)	ns
Pseudoword reading time (in ms.)	646.21 (124.98)	650.17 (127.25)	ns
Raven Progressive Matrix Score (out of 30)	24.83 (2.33)	24.79 (3.24)	ns

Appendix 13. Experiment 1 – French university student groups – Complete results of the background tests.

A13.1. Results of the background tests: comparison between typical and dyslexic-readers.

Appendix-Table 17 below presents the results of French university students, both typical and dyslexic-readers, to the different background tests.

Appendix-Table 17. Results of background tests - French university students, both typical and dyslexic-readers - Experiment 1.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Dialang Level (out of 1,000)	580 (141)	591 (117)	ns
Subtests from the ECLA16+ battery			
« Alouette » Reading time (in sec.)	136.64 (26.58)	90.01 (8.47)	<.001
« Alouette » number of words correctly read (out of 265)	253 (8.91)	260.9 (2.77)	<.01
« Alouette » CTL score (Cavalli et al., 2018)	347.72 (82.27)	526.62 (54.50)	<.001
« Pollueur » number of words correctly read in 1 min (out of 296)	147.06 (27.22)	187.71 (12.86)	<.001
Word dictation score (out of 20)	11.24 (2.84)	15.29 (2.89)	<.001
Word dictation time (in sec.)	105.41 (21.21)	89.05 (12.27)	<.05
Pseudoword dictation score (out of 10)	6.94 (2.25)	8.12 (1.36)	ns
Pseudoword dictation time (in sec.)	56 (9.96)	47.72 (7.49)	<.05
Initial phoneme deletion score (out of 10)	6.59 (2.53)	6.77 (2.68)	ns
Spoonerism score (out of 20)	14.77 (5.02)	18.06 (2.16)	<.05
Symbol barrage score	24.77 (4.97)	23.88 (5.40)	ns
Picture naming time (in sec.)	17.27 (3.35)	13.85 (2.04)	<.01
Letter naming time (in sec.)	24.46 (8.57)	16.42 (2.82)	<.01
Subtests from the ECLA16+ battery			
Number of pseudowords correctly read (out of 36)	27.6 (7.11)	32.53 (3.00)	<.05
Pseudoword reading time (in ms.)	1234.12 (603.85)	636.18 (96.75)	<.01
Raven Progressive Matrix Score (out of 30)	23.77 (3.42)	24.18 (3.23)	ns

A13.2. Results of the background tests: comparison between the sub-groups of typical and dyslexic-readers.

Appendix-Table 18 page 330 presents the results of both sub-groups of French university students, both typical – namely Oral-Written-TypmatchFrUniv (OWTmFU) and Written-Oral-TypmatchFrUniv (WOTmFU) sub-groups – and dyslexic-readers – namely Oral-Written-DysFrUniv (OWDFU) and Written-Oral-DysFrUniv (WODFU) sub-groups, to the different background tests.

Appendix-Table 18. Results of background tests - French university students - Pairings of the subgroups of typical and dyslexic-readers - Experiment 1.

Data	Mean (SD) OWTmFU group	Mean (SD) WOTmFU group	p-value	Mean (SD) OWDFU group	Mean (SD) WODFU group	p-value
Dialang Level (out of 1,000)	585 (81)	597 (147)	ns	511 (121)	641 (134)	ns
Subtests from the ECLA16+ battery						
« Alouette » Reading time (in sec.)	93 (9)	87 (8)	ns	143 (25)	131 (28)	ns
« Alouette » number of words correctly read (out of 265)	261 (3)	261 (3)	ns	263 (4)	265 (0)	ns
« Alouette » CTL score (Cavalli et al., 2018)	508 (57)	543 (50)	ns	319 (66)	373 (90)	ns
« Pollueur » number of words correctly read in 1 min (out of 296)	181 (8)	194 (14)	<.05	139 (27)	155 (27)	ns
Word dictation score (out of 20)	14 (3)	17 (2)	<.05	10 (2)	12 (3)	ns
Word dictation time (in sec.)	91 (13)	87 (12)	ns	105 (21)	106 (23)	ns
Pseudoword dictation score (out of 10)	8 (2)	8 (1)	ns	6 (2)	8 (2)	ns
Pseudoword dictation time (in sec.)	50 (9)	46 (5)	ns	56 (11)	56 (10)	ns
Initial phoneme deletion score (out of 10)	6 (3)	8 (2)	ns	6 (2)	7 (3)	ns
Spoonerism score (out of 20)	18 (2)	18 (2)	ns	13 (6)	17 (3)	ns
Symbol barrage score	24 (5)	24 (6)	ns	26 (4)	24 (6)	ns
Picture naming time (in sec.)	14 (2)	13 (2)	ns	19 (3)	16 (4)	ns
Letter naming time (in sec.)	17 (4)	16 (2)	ns	26 (9)	23 (8)	ns
Subtests from the ECLA16+ battery						
Number of pseudowords correctly read (out of 36)	32 (4)	33 (2)	ns	109 (245)	118 (259)	ns
Pseudoword reading time (in ms.)	676 (97)	601 (87)	ns	1203 (913)	1094 (544)	ns
Raven Progressive Matrix Score (out of 30)	23 (4)	25 (2)	ns	24 (4)	23 (3)	ns

Appendix 14. Experiment 1 – French middle-school student groups – Complete results of the background tests.

A14.1. Results of the background tests: comparison between typical and dyslexic-readers.

Appendix-Table 19 below presents the results of French typical-reader middle-school students to the different background tests, depending on their sub-groups.

Appendix-Table 19. Results of background tests – French typical-reader middle-school students - Experiment 1.

Data	Mean (SD) WOTFM group	Mean (SD) OWTFM group	p-value
Dialang_Level	360.2 (193.01)	313.17 (186.01)	ns
Subtests from the ECLA16+ battery			
« Alouette » Reading time (in sec.)	119.74 (23.51)	117.62 (21.50)	ns
« Alouette » number of words correctly read (out of 265)	248.36 (13.90)	249.57 (8.73)	ns
« Alouette » CTL score (Cavalli et al., 2018)	388.02 (82.48)	393.92 (71.65)	ns
« Polluer » number of words correctly read in 1 min (out of 296)	147.72 (24.35)	153.43 (23.31)	ns
Word dictation score (out of 20)	10.36 (3.58)	10.39 (3.27)	ns
Word dictation time (in sec.)	94.84 (12.12)	92.88 (18.26)	ns
Pseudoword dictation score (out of 10)	7.24 (2.03)	7.65 (1.64)	ns
Pseudoword dictation time (in sec.)	50.68 (5.72)	51.17 (8.34)	ns
Initial phoneme deletion score (out of 10)	6.92 (3.03)	6.87 (2.28)	ns
Spoonerism score (out of 20)	16.12 (2.98)	14.74 (4.85)	ns
Symbol barrage score	17.20 (7.00)	18.04 (5.12)	ns
Picture naming time (in sec.)	16.43 (3.02)	17.35 (2.63)	ns
Letter naming time (in sec.)	20.17 (3.65)	20.84 (4.23)	ns
Subtests from the EVALEC battery			
Number of pseudowords correctly read (out of 36)	30.32 (3.08)	30.70 (2.58)	ns
Pseudoword reading time (in ms.)	921.52 (232.78)	907.17 (274.75)	ns
Raven Progressive Matrix Score (out of 30)	22.60 (2.80)	22.43 (3.09)	ns

A14.2. Results of the background tests: comparison between the groups of typical and dyslexic-readers.

Appendix-Table 20 below presents the results of French middle-school students, both typical and dyslexic-readers to the different background tests.

Appendix-Table 20. Results of background tests – French middle-school students, both typical and dyslexic-readers - Experiment 1.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Dialang_Level	185 (155)	238 (127)	ns
Subtests from the ECLA16+ battery			
« Alouette » Reading time (in sec.)	146.96 (25.32)	122.11 (26.14)	<.05
« Alouette » number of words correctly read (out of 265)	222 (43.56)	248 (8.85)	<.05
« Alouette » CTL score (Cavalli et al., 2018)	284.51 (84.95)	381.90 (85.76)	<.01
« Polluer » number of words correctly read in 1 min (out of 296)	109.71 (28.98)	145.71 (29.32)	<.01
Word dictation score (out of 20)	6.24 (3.03)	9.82 (3.54)	<.05
Word dictation time (in sec.)	114.74 (29.05)	96.56 (20.30)	<.05
Pseudoword dictation score (out of 10)	5.18 (2.98)	6.88 (2.18)	ns
Pseudoword dictation time (in sec.)	61.32 (12.01)	52.00 (8.76)	<.01
Initial phoneme deletion score (out of 10)	4.77 (2.56)	6.12 (2.76)	ns
Spoonerism score (out of 20)	9.88 (6.30)	15.06 (4.19)	<.05
Symbol barrage score	17.77 (5.82)	19.18 (6.18)	ns
Picture naming time (in sec.)	18.98 (4.59)	17.32 (3.35)	ns
Letter naming time (in sec.)	27.08 (7.71)	22.05 (3.79)	<.05
Subtests from the EVALEC battery			
Number of pseudowords correctly read (out of 36)	23.47 (8.05)	30.29 (3.50)	<.05
Pseudoword reading time (in ms.)	1103.47 (341.28)	931.94 (217.37)	Ns
Raven Progressive Matrix Score (out of 30)	21.29 (2.52)	22.71 (3.00)	ns

A14.3. Results of the background tests: comparison between the sub-groups of both typical and dyslexic-readers.

Appendix-Table 21 page 333 presents the results of French middle-school students, both typical – namely Oral-Written-TypmatchFrMid (OWTmFM) and Written-Oral-TypmatchFrMid (WOTmFM) – and dyslexic-readers – namely Oral-Written-DysFrMid (OWDFM) and Written-Oral-DysFrMid (WODFM), to the different background tests.

Appendix-Table 21. Results of background tests - French middle-school students - Pairings of the sub-groups of typical and dyslexic-readers - Experiment 1.

Data	Mean (SD) OWTmFM group	Mean (SD) WOTmFM group	p-value	Mean (SD) OWDFM group	Mean (SD) WODFM group	p-value
Dialang Level (out of 1,000)						
Subtests from the ECLA16+ battery						
« Alouette » Reading time (in sec.)	127 (23)	117 (30)	ns	145 (26)	145 (25)	ns
« Alouette » number of words correctly read (out of 265)	245 (11)	251 (6)	ns	229 (23)	219 (60)	ns
« Alouette » CTL score (Cavalli et al., 2018)	357 (60)	410 (105)	ns	295 (66)	286 (104)	ns
« Pollueur » number of words correctly read in 1 min (out of 296)	151 (24)	151 (35)	ns	111 (16)	110 (40)	ns
Word dictation score (out of 20)	9 (4)	11 (3)	ns	7 (2)	6 (4)	ns
Word dictation time (in sec.)	96 (24)	97 (17)	ns	117 (23)	113 (38)	ns
Pseudoword dictation score (out of 10)	7 (2)	7 (3)	ns	5 (3)	5 (3)	ns
Pseudoword dictation time (in sec.)	53 (11)	51 (6)	ns	64 (12)	58 (13)	ns
Initial phoneme deletion score (out of 10)	6 (3)	6 (3)	ns	5 (2)	5 (3)	ns
Spoonerism score (out of 20)	15 (5)	15 (4)	ns	10 (7)	9 (7)	ns
Symbol barrage score	20 (6)	18 (7)	ns	14 (7)	15 (4)	ns
Picture naming time (in sec.)	19 (3)	16 (3)	ns	21 (5)	18 (4)	ns
Letter naming time (in sec.)	23 (4)	21 (3)	ns	27 (9)	28 (7)	ns
Subtests from the ECLA16+ battery						
Number of pseudowords correctly read (out of 36)	30 (3)	30 (4)	ns	25 (7)	21 (9)	ns
Pseudoword reading time (in ms.)	987 (251)	870 (167)	ns	1055 (286)	1040 (251)	ns
Raven Progressive Matrix Score (out of 30)	23 (2)	23 (4)	ns	20 (2)	22 (3)	ns

Appendix 15. Experiment 1 – English typical-reader university students – Complete results of the background tests.

Appendix-Table 22 below presents the results of English typical-reader university students to the different background tests.

Appendix-Table 22. Results of background tests - English typical-reader university students - Experiment 1.

Data	Mean (SD) WOTEU group	Mean (SD) OWTEU group	p-value
Dialang_Level	237 (159)	224 (142)	ns
Subtests from the YARC battery			
Text reading fluency 1 time (in sec.)	38 (6)	37 (6)	ns
Text reading fluency 2 time (in sec.)	46 (8)	44 (6)	ns
Subtests from the WIAT battery			
Word reading time (in sec.)	37 (10)	34 (9)	ns
Word reading score (out of 131)	127 (4)	127 (3)	ns
Pseudoword reading time (in sec.)	46 (11)	44 (11)	ns
Pseudoword reading score (out of 55)	51 (3)	51 (3)	ns
Word spelling score (out of 53)	46 (4)	46 (4)	ns
Subtests from the ECLA16+ battery			
Symbol barrage score	24.35 (6.70)	23.32 (5.73)	ns
Letter naming time (in sec.)	20.26 (4.89)	17.55 (2.42)	<.05
Raven Progressive Matrix Score (out of 30)	23.10 (3.60)	22.42 (3.67)	ns

Appendix 16. Experiment 1 – Stimuli for the non-cognate task among French university students.

A16.1. Complete pairing between words and pseudowords.

Appendix-Table 23 below presents the complete pairing parameters of words and pseudowords of the non-cognate task for French university students.

Appendix-Table 23. Complete pairing parameters for the stimuli of the non-cognate task - French university students - Experiment 1.

Pairing parameters	Words Mean (SD)	Pseudowords Mean (SD)	p-value
Number of			
Letters	4.80 (1.13)	4.77 (1.16)	ns
Phonemes	4.00 (1.01)	3.91 (0.98)	ns
Syllables	1.39 (.54)	1.39 (0.49)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	.82 (.47)	.88 (.43)	ns	1.00 (.40)	.97 (.44)	ns
Number of neighbours	5.32 (4.85)	4.52 (4.14)	ns	2.82 (3.35)	3.11 (3.75)	ns
Mean frequency of neighbours	134.20 (246.84)	132.24 (185.95)	ns	74.37 (331.76)	92.14 (567.70)	ns
Phonological Neighbourhood						
PLD20	1.31 (.42)	1.38 (.43)	ns	1.12 (.74)	1.11 (.67)	ns
Number of neighbours	9.57 (7.89)	6.50 (5.67)	**.06**	2.89 (6.81)	2.11 (6.42)	ns
Mean frequency of neighbours	198.09 (310.48)	125.20 (166.34)	ns	1.34 (3.36)	1.45 (4.32)	ns
Orthographic Markedness						
Mean letter frequency	57616 (9612)	58834 (10753)	ns	67679 (15413)	70742 (16259)	ns
Minimum letter frequency	21475 (9007)	21986 (13621)	ns	15923 (13896)	17145 (20220)	ns
Mean bigram frequency	7461 (3326)	6447 (2655)	ns	5976 (2761)	6864 (3517)	ns
Minimum bigram frequency	1665 (858)	1824 (1618)	ns	530 (824)	595 (1045)	ns
Mean trigram frequency	2933 (2322)	2968 (2264)	ns	425 (422)	634 (799)	**.06**
Minimum trigram frequency	219 (185)	202 (258)	ns	58 (132)	68 (139)	ns

A16.2. Complete lists of stimuli.

A19.2.1. Words.

aim, anger, attic, baker, bean, belt, blind, breath, bunch, ceiling, chicken, crew, dish, dry, dull, duty, frame, garlic, gift, glad, guilty, heaven, honey, hook, ladder, leaf, level, loss, mistake, mood, neck, purple, sand, shame, sharp, shoulder, sight, sink, smoke, truth, wet, wind, wing, wool.

A19.2.2. Pseudowords.

arker, attay, aze, bealing, beft, blith, bozer, brooth, bry, burge, chacken, cred, dimp, duse, frad, frane, geardy, goft, hool, hotey, hounen, kond, lammer, lodel, loff, mistyle, murgle, musy, nell, rif, rin, shail, sharf, shielder, sint, sitch, smike, tink, trith, wartic, wess, wike, wook, yond.

Appendix 17. Experiment 1 – Stimuli for the cognate task among French university students.

A17.1. Complete pairing between words and pseudowords, and between cognate and non-cognate words.

Appendix-Table 24 below presents the complete pairing parameters of words and pseudowords, and between cognate and non-cognate words, of the cognate task for French university students.

Appendix-Table 24. Complete pairing parameters for the stimuli of the cognate task - French university students - Experiment 1.

	Cognate words Mean (SD)	Non-cognate words Mean (SD)	p-value	Words Mean (SD)	Pseudowords Mean (SD)	p-value
Number of						
Letters	6.9 (1.90)	5.03 (1.22)	**<.001**	5.98 (1.87)	6.00 (1.85)	ns
Phonemes	6.3 (1.58)	4.3 (1.15)	**<.001**	5.33 (1.72)	5.33 (1.90)	ns
Syllables	2.4 (0.86)	1.4 (0.57)	**<.001**	1.95 (0.89)	1.97 (0.90)	ns

	Within-language parameters (in English)					
	Cognate words Mean (SD)	**Non-cognate words** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.26 (0.47)	1.16 (0.60)	ns	1.23 (.56)	1.25 (0.62)	ns
Number of neighbours	2.3 (4.45)	3.17 (2.12)	ns	2.67 (3.18)	3.07 (3.96)	ns
Mean frequency of neighbours	47.10 (132.89)	73.55 (163.71)	ns	63.73 (153.43)	66.71 (139.10)	ns
Phonological Neighbourhood						
PLD20	1.69 (0.53)	1.48 (0.46)	**.09**	1.59 (0.50)	1.66 (0.55)	**.09**
Number of neighbours	4.47 (6.52)	6.73 (5.07)	**.08**	5.48 (6.71)	3.09 (3.94)	ns
Mean frequency of neighbours	46.07 (99.78)	61.15 (72.98)	ns	57.32 (94.67)	66.93 (139.00)	ns
Orthographic Markedness						
Mean letter frequency	61462 (15334)	61738 (14172)	ns	61643 (11109)	62286 (12050)	ns
Minimum letter frequency	25572 (23353)	23323 (12714)	ns	24395 (14453)	25061 (14860)	ns
Mean bigram frequency	6543 (2023)	5895 (2514)	ns	6196 (2306)	6473 (2574)	ns
Minimum bigram frequency	1733 (1900)	1588 (998)	ns	1665 (1530)	1825 (1508)	ns
Mean trigram frequency	2808 (1352)	2476 (1614)	ns	2595 (1489)	2751 (1587)	ns
Minimum trigram frequency	160 (123)	161 (134)	ns	160 (128)	134 (135)	ns

	Between-language parameters (in French)					
	Cognate words Mean (SD)	Non-cognate words Mean (SD)	p-value	Words Mean (SD)	Pseudowords Mean (SD)	p-value
Orthographic Neighbourhood						
OLD20	1.16 (0.54)	1.05 (0.50)	ns	1.12 (0.52)	1.26 (0.59)	ns
Number of neighbours	2.67 (4.40)	2.5 (3.09)	ns	2.58 (3.77)	2.41 (4.45)	ns
Mean frequency of neighbours	8.60 (13.90)	24.51 (94.66)	ns	17.05 (68.68)	10.77 (43.67)	**.08**
Phonological Neighbourhood						
PLD20	2.00 (0.86)	1.89 (0.70)	ns	1.95 (0.78)	1.77 (0.94)	ns
Number of neighbours	0 (0)	0.97 (3.74)	**.06**	0.50 (2.71)	0.29 (1.74)	ns
Mean frequency of neighbours	0 (0)	1.62 (7.35)	ns	0.84 (5.31)	1.68 (12.46)	ns
Orthographic Markedness						
Mean letter frequency	72790 (22823)	77351 (32973)	ns	75070 (28210)	75508 (17511)	ns
Minimum letter frequency	23997 (19878)	19733 (14879)	ns	21865 (17540)	22068 (21471)	ns
Mean bigram frequency	7807 (2550)	7506 (10572)	ns	7657 (7626)	7532 (4166)	ns
Minimum bigram frequency	1833 (2251)	471 (768)	**<.01**	1152 (1803)	1235 (1579)	ns
Mean trigram frequency	1044 (478)	894 (1120)	ns	969 (857)	767 (739)	ns
Minimum trigram frequency	119 (108)	97 (133)	ns	108 (120)	96 (152)	ns

A17.2. Complete lists of stimuli.

A20.2.1. Words.

French-English identical cognates: accident, application, architecture, excuse, garage, global, incident, menu, rare, regret, rival, section, signal, signature, tropical.

French-English non-identical cognates: access, adult, alcohol, apartment, classical, economy, exchange, flame, honest, majority, onion, paradise, powder, private, sense.

French-English non-cognates: brand, cow, currency, deep, doll, drum, drunk, faith, handsome, joke, lamb, lift, lorry, luck, nasty, noisy, pride, rogue, roof, seaside, shape, shed, smelly, spoon, steam, tiny, towel, wealth, wicked, witness.

A20.2.2. Pseudowords.

abbliration, accibate, afress, alpowel, anilement, arthitacture, blunk, brape, brate, clammical, currenby, drom, ecanory, exbuse, exchaine, fearn, feep, flape, fow, gacked, garock, glibal, grubical, handsall, homel, horest, incigate, jore, lage, lide, lidy, lunk, moof, nispy, odult, oroon, paladent, poharity, ponu, prinate, purder, rebrel, ricel, roise, rore, sanse, seasile, seclion, sheed, signanise, sildal, smanty, spoop, stean, tride, turry, wayness, weafed, wisty, woll.

Appendix 18. Experiment 1 – Stimuli for the non-cognate task among French middle-school students.

A18.1. Complete pairing between words and pseudowords.

Appendix-Table 25 below presents the complete pairing parameters of words and pseudowords of the non-cognate task for French middle-school students.

Appendix-Table 25. Complete pairing parameters for the stimuli of the non-cognate task - French middle-school students - Experiment 1.

Pairing parameters	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Number of			
Letters	5.28 (1.06)	5.25 (1.10)	ns
Phonemes	4.28 (.99)	4.50 (1.04)	ns
Syllables	1.53 (.55)	1.50 (.51)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.04 (.48)	1.11 (.50)	ns	1.10 (.40)	1.12 (.47)	ns
Number of neighbours	3.63 (3.81)	3.35 (4.09)	ns	1.40 (2.06)	2.48 (4.77)	ns
Mean frequency of neighbours	117.63 (300.57)	91.26 (176.83)	ns	15.15 (76.97)	14.94 (29.41)	ns
Phonological Neighbourhood						
PLD20	1.03 (.50)	1.13 (.62)	ns	1.69 (.57)	1.60 (.71)	ns
Number of neighbours	5.53 (5.69)	4.13 (5.88)	ns	.05 (.22)	.30 (1.74)	ns
Mean frequency of neighbours	156.66 (318.46)	88.80 (142.37)	ns	.01 (.04)	.14 (.86)	ns
Orthographic Markedness						
Mean letter frequency	58566 (9503)	59266 (9050)	ns	69349 (13265)	71622 (13637)	ns
Minimum letter frequency	21639 (9530)	23545 (12368)	ns	16742 (14854)	20025 (21000)	ns
Mean bigram frequency	7924 (2839)	8181 (2893)	ns	6316 (2651)	6985 (3028)	ns
Minimum bigram frequency	1453 (1181)	1514 (1748)	ns	682 (1092)	728 (1235)	ns
Mean trigram frequency	4586 (2639)	4881 (2945)	ns	563 (376)	688 (797)	ns
Minimum trigram frequency	147 (146)	132 (186)	**<.05**	68 (133)	81 (139)	ns

A18.2.Complete lists of stimuli.

A21.2.1.Words.

alive, aloud, bean, blind, bottom, breath, chicken, church, crew, crowd, crown, dirty, dry, empty, flour, foreign, gift, heaven, honey, level, mistake, mood, murder, pencil, purple, purpose, rabbit, sand, scarf, shoulder, shower, sink, smile, smoke, speed, stone, truth, wind, wing, wonder.

A21.2.2.Pseudowords.

alace, amoad, bettoy, blith, brooth, bry, chacken, churge, cred, crope, elfry, goft, growd, hotey, hounen, kond, lodel, lopeign, menvil, misky, mistyle, murgle, murpore, preed, rabbel, rin, rumder, scarb, shielder, shimer, sint, smale, smike, spour, stong, tink, trith, wike, wormer, yond.

Appendix 19. Experiment 1 – Stimuli for the cognate task among French middle-school students.

A19.1. Complete pairing between words and pseudowords, and between cognate and non-cognate words.

Appendix-Table 26 below presents the complete pairing parameters of words and pseudowords, and between cognate and non-cognate words, of the cognate task for French middle-school students.

Appendix-Table 26. Complete pairing parameters for the stimuli of the cognate task - French middle-school students - Experiment 1.

Pairing parameters	**Cognate words** Mean (SD)	**Non-cognate words** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Number of						
Letters	6.57 (.97)	6.00 (.83)	**<.05**	6.28 (.94)	6.28 (.94)	ns
Phonemes	5.93 (1.34)	5.00(.91)	**<.01**	5.47 (1.23)	5.57 (1.24)	ns
Syllables	2.23(.63)	1.73 (.45)	**<.001**	1.98 (.60)	1.98 (.62)	ns
	Within-language parameters (in English)					
	Cognate words Mean (SD)	**Non-cognate words** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.31 (.37)	1.18 (.44)	ns	1.24 (.41)	1.36 (.46)	ns
Number of neighbours	1.33 (1.52)	2.00 (1.66)	ns	1.67 (1.61)	1.42 (1.67)	ns
Mean frequency of neighbours	29.21 (56.42)	61.48 (81.99)	ns	45.34 (71.65)	36.62 (68.66)	ns
Phonological Neighbourhood						
PLD20	1.60 (.48)	1.39 (.63)	ns	1.50 (.57)	1.62 (.51)	ns
Number of neighbours	2.80 (3.22)	4.13 (3.77)	ns	3.47 (3.54)	2.25 (3.19)	ns
Mean frequency of neighbours	42.70 (56.25)	87.82 (135.16)	ns	65.26 (105.13)	40.72 (77.18)	ns
Orthographic Markedness						
Mean letter frequency	64949 (9450)	61284 (12698)	ns	62617 (11343)	62590 (10873)	ns
Minimum letter frequency	26486 (14369)	20199 (7612)	**<.05**	23342 (11833)	22631 (11085)	ns
Mean bigram frequency	8303 (2707)	7288 (2414)	ns	7796 (2594)	8304 (2773)	ns
Minimum bigram frequency	1664 (1470)	1323 (1161)	ns	1494 (1324)	1563 (1452)	ns
Mean trigram frequency	4595 (2392)	3658 (1699)	ns	4126 (2111)	4583 (2274)	ns
Minimum trigram frequency	138 (133)	128 (123)	ns	133 (127)	109 (121)	ns

	Between-language parameters (in French)					
	Cognate words Mean (SD)	Non-cognate words Mean (SD)	p-value	Words Mean (SD)	Pseudowords Mean (SD)	p-value
Orthographic Neighbourhood						
OLD20	1.08 (.52)	1.29 (.45)	ns	1.19 (.49)	1.27 (.46)	ns
Number of neighbours	2.03 (2.04)	1.27 (1.93)	ns	1.65 (2.01)	1.12 (1.65)	ns
Mean frequency of neighbours	17.13 (60.50)	4.07 (19.69)	ns	10.60 (45.09)	7.60 (20.63)	ns
Phonological Neighbourhood						
PLD20	1.59 (.60)	1.19 (.75)	**<.05**	1.39 (.72)	1.41 (.72)	ns
Number of neighbours	.13 (.73)	0 (0)	ns	.07 (.52)	.12 (.56)	ns
Mean frequency of neighbours	.29 (1.60)	0 (0)	ns	.15 (1.13)	2.27 (14.13)	ns
Orthographic Markedness						
Mean letter frequency	77177 (13281)	75993 (14491)	ns	76585 (13794)	78745 (13560)	ns
Minimum letter frequency	27429 (22790)	24250 (19220)	ns	25839 (20963)	23188 (16219)	ns
Mean bigram frequency	8600 (3147)	7031 (3136)	ns	7816 (3213)	8870 (3334)	ns
Minimum bigram frequency	1645 (1824)	985 (1620)	ns	1315 (1742)	1138 (1141)	ns
Mean trigram frequency	1253 (1144)	1013 (1225)	ns	1133 (1182)	1162 (1037)	ns
Minimum trigram frequency	324 (778)	123 (260)	ns	223 (584)	117 (178)	ns

A19.2. Complete lists of stimuli.

A22.2.1. Words.

French-English identical cognates: accident, chance, courage, danger, direct, double, excuse, garage, global, incident, machine, menu, nation, section, signature.

French-English non-identical cognates: access, bubble, carrot, center, collect, control, majority, nervous, private, profile, reality, reason, salad, student, theater.

French-English non-cognates: awesome, baking, brand, bright, calling, closed, deep, diving, driver, drunk, feeling, health, helmet, hiking, hunger, luck, luggage, meaning, melting, mouth, peanut, release, rubber, silver, spider, steam, unfair, waiter, winner, witness.

A22.2.2. Pseudowords.

accibate, afress, apesome, bearage, bester, blunk, brance, brate, buddle, carad, carvet, clight, clomes, collish, constil, deapon, diride, driper, exbuse, feep, garock, gaster, glibal, hearch, henser, hildet, huling, incigate, laking, lunk, lussage, mescone, miling, moupe, mouring, nambous, naroon, poharity, plover, ponu, porgale, poodle, prinate, prument, rander, rasting, reaput, releant, reunaty, rolting, ruffer, seclion, signanise, slover, stean, tealing, theamer, unfept, wayness, wender.

Appendix 20. Experiment 1 – Stimuli for the cognate task among English typical-reader university students.

A20.1. Complete pairing between words and pseudowords, and between cognate and non-cognate words.

Appendix-Table 27 below presents the complete pairing parameters of words and pseudowords of the cognate task for English university students.

Appendix-Table 27. Complete pairing parameters for the stimuli of the cognate task – English university students - Experiment 1.

Pairing parameters	Cognate words Mean (SD)	Non-cognate words Mean (SD)	p-value	Words Mean (SD)	Pseudowords Mean (SD)	p-value
Number of						
Letters	8.10 (2.09)	7.33 (1.79)	ns	7.72 (1.97)	7.72 (1.97)	ns
Phonemes	6.70 (2.00)	5.17 (1.44)	**<.01**	5.93 (1.89)	5.85 (1.59)	ns
Syllables	2.70(.84)	2.03 (.85)	**<.01**	2.37 (.90)	2.40 (.91)	ns

	Within-language parameters (in English)					
	Cognate words Mean (SD)	**Non-cognate words** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.27 (.45)	1.14 (.48)	ns	1.21 (.47)	1.32 (.53)	ns
Number of neighbours	.80 (1.00)	1.97 (1.77)	**<.01**	1.38 (1.54)	1.18 (1.68)	ns
Mean frequency of neighbours	16.76 (15.33)	27.74 (48.91)	ns	17.25 (37.46)	20.70 (50.54)	ns
Phonological Neighbourhood						
PLD20	1.69 (1.21)	1.02 (1.11)	ns	1.36 (1.20)	1.51 (.79)	ns
Number of neighbours	6.50 (3.24)	8.10 (10.42)	ns	5.30 (8.15)	5.07 (10.19)	ns
Mean frequency of neighbours	14.43 (44.36)	22.81 (43.56)	ns	18.62 (43.79)	18.11 (48.66)	ns
Orthographic Markedness						
Mean letter frequency	63706 (11542)	68278 (9085)	ns	65992 (10553)	63219 (10661)	ns
Minimum letter frequency	18512 (17851)	16620 (14960)	ns	17566 (16357)	17819 (13605)	ns
Mean bigram frequency	4777 (1825)	5775 (1766)	**<.05**	5276 (1850)	4905 (1791)	ns
Minimum bigram frequency	110 (351)	61 (298)	ns	86 (324)	65 (365)	ns
Mean trigram frequency	1439 (932)	1851 (958)	ns	1645 (960)	1505 (849)	ns
Minimum trigram frequency	26 (65)	36 (83)	ns	31 (74)	13 (33)	ns

	Between-language parameters (in French)					
	Cognate words Mean (SD)	**Non-cognate words** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.49 (.50)	1.50 (.50)	ns	1.49 (.50)	1.56 (.53)	ns
Number of neighbours	.77 (1.17)	.17 (.46)	**<.05**	.47 (.93)	.27 (.71)	ns
Mean frequency of neighbours	3.62 (6.55)	2.34 (7.77)	ns	2.98 (7.16)	1.52 (5.02)	ns
Phonological Neighbourhood						
PLD20	1.71 (.67)	1.12 (.67)	**<.01**	1.41 (.73)	1.81 (.75)	**<.05**
Number of neighbours	.07 (.37)	.73 (3.30)	ns	.40 (2.35)	.20 (.66)	ns
Mean frequency of neighbours	.02 (.10)	17.14 (78.96)	ns	8.58 (56.03)	1.11 (4.59)	ns
Orthographic Markedness						
Mean letter frequency	60745 (10443)	64839 (9890)	ns	62792 (10293)	61903 (8332)	ns
Minimum letter frequency	17059 (16762)	19202 (13461)	ns	18130 (15110)	17817 (10444)	ns
Mean bigram frequency	6469 (2980)	8498 (3544)	**<.05**	7484 (3404)	9410 (14859)	ns
Minimum bigram frequency	1007 (1000)	1159 (936)	ns	1083 (963)	3059 (15381)	ns
Mean trigram frequency	3174 (2462)	4754 (3991)	ns	3964 (3383)	6121 (15289)	ns
Minimum trigram frequency	56 (65)	102 (182)	ns	79 (138)	2051 (15487)	ns

A20.2. Complete lists of stimuli.

A23.2.1. Words.

French-English identical cognates: accent, administration, affection, canal, cancer, collaboration, collection, discussion, excellent, exception, execution, humour, relation, tennis, tribunal.

French-English non-identical cognates: avril, combattre, défendre, délicieux, fameux, généreux, joyeux, maintenir, mystérieux, octobre, paradis, prévenir, progrès, retenir, septembre.

French-English non-cognates: abattre, amené, atteindre, auparavant, chacune, craindre, douloureux, douze, drôlement, falloir, gentiment, instituteur, ivre, jument, larme, mâchoire, malheureux, marteau, mentir, mouchoir, naître, œuf, paraître, promener, refaire, résoudre, rompre, sachant, soutenir, vaincre.

A23.2.2. Pseudowords.

acalé, acrit, affaindre, anlicentration, arvent, asustre, sttuction, autaracont, barceau, bendir, bombre, bouchoir, broindre, cascession, chisunal, commoître, coraire, costaction, décipieur, déforche, donnis, doutouroie, épre, étrullent, exilutien, expoution, favaux, goincre, gratule, hémoir, instarétien, iouf, jemant, joître, joyard, lontident, loube, malsairaux, meintenot, muttérieur, obsocre, pagnant, manver, pâtraire, paval, pavedas, pavrable, plogros, précasir, propaler, récuitre, rémélir, ressaporation, revétain, rhylament, sectempre, soumelir, tallier, targe, vénérial.

Appendix 21. Experiment 2 – French stimuli for the non-cognate task among French university students.

A21.1. Complete pairings between words and pseudowords.

Appendix-Table 28 below presents the complete pairing parameters of French words and pseudowords of the non-cognate task for French university students.

Appendix-Table 28. Complete pairing parameters for L1 stimuli - French university students - Experiment 2.

Pairing parameters	Words Mean (SD)	Pseudowords Mean (SD)	p-value
Number of			
Letters	6.71 (1.49)	6.71 (1.49)	ns
Phonemes	5.37 (1.34)	5.49 (1.31)	ns
Syllables	2.20 (.56)	2.22 (.57)	ns

	Within-language parameters (in French)			**Between-language parameters (in English)**		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.07 (.42)	1.15 (.47)	ns	1.72 (.35)	1.71 (.40)	ns
Number of neighbours	2.85 (2.15)	2.44 (2.80)	ns	.44 (1.14)	.59 (1.56)	ns
Mean frequency of neighbours	6.46 (12.20)	6.70 (16.10)	ns	9.97 (33.50)	92.14 (567.70)	ns
Phonological Neighbourhood						
PLD20	.56 (.62)	.60 (.65)	ns	2.00 (.27)	2.06 (.31)	ns
Number of neighbours	12.95 (14.64)	14.44 (20.37)	ns	.07 (.35)	.59 (1.56)	ns
Mean frequency of neighbours	4.46 (7.65)	6.27 (16.41)	ns	6.13 (38.66)	19.00 (66.74)	ns
Orthographic Markedness						
Mean letter frequency	80335 (10830)	79832 (9714)	ns	61497 (8733)	61227 (8571)	ns
Minimum letter frequency	25370 (14333)	25860 (12816)	ns	19030 (11633)	20488 (12404)	ns
Mean bigram frequency	8436 (2794)	9070 (2564)	ns	6401 (2133)	6687 (2175)	ns
Minimum bigram frequency	1581 (1306)	1778 (1245)	ns	1350 (1087)	1649 (1306)	ns
Mean trigram frequency	1160 (909)	1105 (513)	ns	4227 (2979)	4359 (2871)	ns
Minimum trigram frequency	115 (110)	131 (140)	ns	1060 (4384)	1729 (7863)	ns

A21.2. Complete lists of stimuli.

A24.2.1. Words.

abordage, argot, bagout, baudet, bélier, bijoutier, boulon, cinéaste, colleur, compère, copeau, diadème, dompteur, embout, fétu, fiel, filage, finaud, fisc, gaspillage, jardinage, jarret, linceul, mangeur, matelot, merlan, nageur, parleur, preneur, putois, rapt, rossignol, sablier, sarment, séisme, serrurier, sparadrap, surjet, tournevis, tracas, tuteur.

A24.2.2. Pseudowords.

adangage, ancot, baduit, bardain, bauget, béhouteur, berlan, bouran, callier, cénoyate, coadège, codieu, coltère, dureur, empiet, félu, fial, finiat, firs, fourbavis, hadeur, jallet, lemminage, linsoul, loncteur, mamenot, mardeur, méisse, mérier, panveur, pruneur, purias, ract, raplier, russofloc, sindurier, smaracrel, surpit, telade, trapis, vordillage.

Appendix 22. Experiment 2 – French stimuli for the non-cognate task among French middle-school students.

A22.1. Complete pairings between words and pseudowords.

Appendix-Table 29 below presents the complete pairing parameters of French words and pseudowords of the non-cognate task for French middle-school students.

Appendix-Table 29. Complete pairing parameters for L1 stimuli - French middle-school students - Experiment 2.

Pairing parameters	Words Mean (SD)	Pseudowords Mean (SD)	p-value
Number of			
Letters	6.94 (1.59)	6.94 (1.59)	ns
Phonemes	5.71 (1.32)	5.74 (1.39)	ns
Syllables	2.26 (.63)	2.29 (.64)	ns

	Within-language parameters (in French)			**Between-language parameters (in English)**		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.14 (.46)	1.22 (.52)	ns	1.73 (.40)	1.74 (.44)	ns
Number of neighbours	2.97 (2.44)	2.35 (3.01)	ns	.58 (1.29)	.68 (1.78)	ns
Mean frequency of neighbours	4.34 (7.42)	6.40 (16.95)	ns	13.18 (38.12)	23.90 (76.26)	ns
Phonological Neighbourhood						
PLD20	.72 (.62)	.71 (.68)	ns	2.07 (.25)	2.11 (.33)	ns
Number of neighbours	11.65 (16.03)	12.77 (18.34)	ns	.10 (.40)	.68 (1.78)	ns
Mean frequency of neighbours	2.97 (6.27)	7.26 (18.75)	ns	8.10 (44.46)	23.90 (76.26)	ns
Orthographic Markedness						
Mean letter frequency	82316 (9890)	80665 (8190)	ns	63262 (6675)	61670 (5617)	ns
Minimum letter frequency	26077 (14970)	25489 (13732)	ns	19259 (12115)	19413 (12738)	ns
Mean bigram frequency	8622 (2673)	9320 (2586)	ns	6921 (2016)	7110 (1872)	ns
Minimum bigram frequency	1540 (1338)	1666 (1104)	ns	1422 (1175)	1587 (1298)	ns
Mean trigram frequency	1087 (502)	1151 (472)	ns	3314 (2325)	3530 (2412)	ns
Minimum trigram frequency	100 (86)	114 (106)	ns	1402 (5013)	2287 (9006)	ns

A22.2.Complete lists of stimuli.

A25.2.1.Words.

abordage, argot, bélier, bijoutier, boulon, cinéaste, compère, diadème, dompteur, fiel, fisc, gaspillage, jardinage, jarret, linceul, mangeur, matelot, merlan, nageur, parleur, preneur, putois, rapt, rossignol, sablier, séisme, serrurier, sparadrap, tournevis, tracas, tuteur.

A25.2.2.Pseudowords.

adangage, ancot, béhouteur, berlan, bouran, cénoyate, coadège, coltère, dureur, fial, firs, fourbavis, hadeur, jallet, lemminage, linsoul, loncteur, mamenot, mardeur, méisse, mérier, panveur, pruneur, purias, ract, raplier, russofloc, sindurier, smaracrel, trapis, vordillage.

Appendix 23. Experiment 2 – English stimuli for the non-cognate task among English university students.

A23.1.Complete pairings between words and pseudowords.

Appendix-Table 30 below presents the complete pairing parameters of English words and pseudowords of the non-cognate task for English university students.

Appendix-Table 30. Complete pairing parameters for L1 stimuli – English university students - Experiment 2.

Pairing parameters	Words Mean (SD)	Pseudowords Mean (SD)	p-value
Number of			
Letters	7.05 (1.74)	7.05 (1.74)	ns
Phonemes	5.65 (1.67)	6.00 (1.52)	ns
Syllables	1.85 (.77)	1.80 (.72)	ns

	Within-language parameters (in French)			Between-language parameters (in English)		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.87 (.68)	1.97 (.74)	ns	2.80 (.82)	2.84 (.78)	ns
Number of neighbours	2.98 (3.53)	3.03 (3.53)	ns	.35 (1.05)	.38 (1.03)	ns
Mean frequency of neighbours	12.01 (22.44)	21.12 (58.81)	ns	4.50 (19.91)	3.06 (9.50)	ns
Phonological Neighbourhood						
PLD20	2.14 (.89)	2.32 (.80)	ns	4.69 (1.66)	4.05 (1.79)	ns
Number of neighbours	5.35 (5.49)	4.50 (6.03)	ns	.33 (1.44)	.38 (1.03)	ns
Mean frequency of neighbours	13.67 (20.54)	21.39 (58.73)	ns	4.79 (20.41)	3.06 (9.50)	ns
Orthographic Markedness						
Mean letter frequency	52575 (15838)	52963 (13713)	ns	60129 (14658)	58965 (10989)	ns
Minimum letter frequency	14339 (10540)	14220 (10658)	ns	12755 (13294)	12369 (13461)	ns
Mean bigram frequency	6043 (2449)	6227 (2619)	ns	3574 (1862)	3467 (1994)	ns
Minimum bigram frequency	946 (875)	919 (842)	ns	7 (10)	7 (11)	ns
Mean trigram frequency	2044 (1288)	2410 (1626)	ns	587 (715)	522 (611)	ns
Minimum trigram frequency	34 (63)	22 (41)	ns	1 (3)	1 (1)	ns

A23.2. Complete lists of stimuli.

A26.2.1. Words.

battering, bickering, blatantly, bullied, bushy, catchment, cling, corkscrew, crib, demeanour, disagreed, drilling, enabled, flavouring, flawless, fondly, fulfilling, giggle, gruelling, hovering, nudge, pageant, postpone, reeling, rubbing, ruck, shale, shaping, shrug, sleet, snail, snuff, staged, steamed, stormed, thatched, thrilling, thrive, tread, tripping.

A26.2.2. Pseudowords.

barchment, beldy, blatched, braming, broviering, buttied, clatently, compstrew, crub, decoonear, disaspoon, feltering, felvilling, fentering, fimbly, frinking, futering, giddle, imatred, nedge, pluetting, portbone, raleant, reaking, rugging, runk, shand, shapping, shrum, sloot, snamb, snuch, spawless, sping, sprinking, starpt, stoomed, storked, thrist, troud.

Appendix 24. Experiment 3 – French university student groups - Demographic data of the sub-groups.

A24.1. French typical-reader university students.

Appendix-Table 31 below presents the demographic data of both sub-groups of French typical-reader university students – namely written-TypFrUniv (wTFU) and oral-TypFrUniv (oTFU), as well as the statistics comparing those sub-groups.

Appendix-Table 31. Demographic data - French typical-reader university students - Experiment 3.

Data	Mean (SD) oTFU group	Mean (SD) wTFU group	p-value
Age	26 (5)	27 (6)	ns
Gender (% of Female)	68	81	ns
Laterality (% of Right-handed)	93	94	ns
Age of formal acquisition of English as an L2	10 (2)	9 (2)	ns
Socio-economic status	3.72 (2.40)	3.46 (2.20)	ns

A24.2. French university students, both typical and dyslexic-readers.

Appendix-Table 32 page 353 presents the demographic data of the sub-groups of French university students, both typical – namely written-TypFrUnivMatched (wTFUM) and oral-TypFrUnivMatched (oTFUM) sub-groups – and dyslexic-readers – namely written-DysFrUniv (wDFU) and oral-DysFrUniv (oDFU) sub-groups, as well as the statistics comparing those sub-groups.

Appendix-Table 32. Demographic data - French university students, both typical and dyslexic-readers - Experiment 3.

Data	Mean (SD) oDFU sub-group	Mean (SD) wDFU sub-group	p-value	Mean (SD) oTFUM sub-group	Mean (SD) wTFUM sub-group	p-value
Age	29 (4)	27 (4)	ns	28 (4)	28 (4)	ns
Gender (% of Female)	46	43	ns	67	100	ns
Laterality (% of Right-handed)	100	100	ns	92	100	ns
Age of formal acquisition of English as an L2	9 (2)	9 (3)	ns	9 (2)	9 (2)	ns
L2 Proficiency (DL out of 1,000)	537 (272)	404 (282)	ns	557 (228)	517 (173)	ns
SRT	309 (43)	311 (26)	ns	297 (34)	299 (40)	ns
CRT	478 (80)	472 (35)	ns	468 (64)	490 (79)	ns

Appendix 25. Experiment 3 – French university students – pairings between typical and dyslexic-readers.

Appendix-Table 33 below presents the pairings between French typical and dyslexic-reader university students of Experiment 3.

Appendix-Table 33. Pairings between typical and dyslexic-readers - French university students - Experiment 3.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Age	28 (4)	28 (4)	ns
Gender (% of Female)	45	80	ns
Laterality (% of Right-handed)	100	95	ns
Age of formal acquisition of English as an L2	9 (2)	10 (2)	ns
L2 Proficiency (DL out of 1,000)	491 (275)	541 (204)	ns
Order of presentation of modalities (% of WO)	65	65	ns
SRT	310 (37)	298 (36)	ns
CRT	476 (67)	477 (70)	ns

Appendix 26. Experiment 3 – French university student groups – Complete analysis of answers of the sub-groups to the Adult Reading Habits Questionnaire.

A26.1. French typical-reader university students.

Appendix-Table 34 below presents the answers of both sub-groups of French typical-reader university students –namely written-TypFrUniv (wTFU) and oral-TypFrUniv (oTFU), to the Adult Reading Habits Questionnaire, as well as the statistics comparing those sub-groups. Most of questions were asked on a five-point Likert scale: the higher the value of the answer, the higher the ability to read for example. Conversely, the question concerning frequencies were asked on a four-point Likert scale: the lower the value of the answer, the higher the frequency of behaviour.

Appendix-Table 34. Questionnaire - French typical-reader university students - Experiment 3.

Data	Mean (SD) wTFU group	Mean (SD) oTFU group	p-value
Attitude toward primary school	3.91 (.91)	4.00 (.93)	ns
Difficulties learning to read in primary school	4.68 (.60)	4.85 (.42)	ns
Help learning to read in primary school	4.23 (1.22)	4.52 (1.07)	ns
Reading level, compared to peers, in primary school	3.86 (.85)	3.96 (.83)	ns
Reading speed, compared to peers, in primary school	4.18 (.66)	4.30 (.51)	ns
Judgment of reading activity in primary school	3.68 (1.09)	3.89 (.84)	ns
Number of books read per year for pleasure in primary school	3.45 (1.27)	3.43 (1.19)	ns
Difficulties learning orthography in primary school	4.20 (.82)	4.32 (.89)	ns
Tendency to reverse letters or digits in primary school	4.41 (.87)	4.77 (.70)	ns
Difficulties learning the names of people or places in primary school	4.95 (.21)	4.94 (.32)	ns
Amount of work to complete in primary school, compared to peers	4.39 (.84)	4.40 (.88)	ns
Actual difficulties to read	4.91 (.29)	4.96 (.20)	ns
Actual time spent to read per day	4.07 (.97)	4.13 (.99)	ns
Actual number of books read per year for pleasure	3.23 (1.26)	3.47 (1.16)	ns
Actual reading speed, compared to peers	4.14 (.63)	4.11 (.67)	ns
Actual difficulties in writing without spelling mistakes	4.55 (.50)	4.62 (.53)	ns
Actual tendency to reverse letters or digits	4.73 (.54)	4.91 (.35)	ns
Actual difficulties in remembering names of people and places	4.45 (.87)	4.40 (.77)	ns

Data	Mean (SD) wTFU group	Mean (SD) oTFU group	p-value
Exposure to French language	1.07 (.26)	1.08 (.27)	ns
Exposure to English language	2.46 (.93)	2.60 (1.05)	ns
Frequency of listening to music in French language	1.57 (.95)	1.64 (.79)	ns
Frequency of listening to music in English language	1.39 (.72)	1.21 (.55)	ns
Frequency of listening to music in another language	2.70 (1.19)	2.70 (1.04)	ns
Frequency of reading in French language	1.00 (.00)	1.06 (.25)	ns
Frequency of reading in English language	1.91 (1.03)	1.77 (.98)	ns
Frequency of reading in another language	3.30 (.93)	3.43 (.93)	ns
Frequency of watching videos in French language	1.14 (.51)	1.09 (.46)	ns
Frequency of watching videos in English language	1.70 (.90)	1.60 (.90)	ns
Frequency of watching videos in another language	3.20 (1.00)	3.17 (.99)	ns
Frequency of playing video-games in French language	2.59 (1.23)	2.51 (1.35)	ns
Frequency of playing video-games in English language	3.14 (1.15)	3.00 (1.22)	ns
Frequency of playing video-games in another language	3.95 (.21)	3.96 (.29)	ns
Socio-economic status	3.72 (2.40)	3.46 (2.20)	ns

A26.2. French university students, both typical and dyslexic-readers.

Appendix-Table 35 below presents the answers of both typical and dyslexic-readers to the Adult Reading Habits Questionnaire, as well as the statistics comparing those groups.

Appendix-Table 35. Questionnaire - French university students: comparison between typical and dyslexic-readers - Experiment 3.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Attitude toward primary school	3.10 (1.07)	4.00 (.86)	<.01
Difficulties learning to read in primary school	2.70 (.80)	4.90 (.31)	<.001
Help learning to read in primary school	2.14 (1.34)	4.80 (.62)	<.001
Reading level, compared to peers, in primary school	2.40 (1.00)	4.15 (.81)	<.001
Reading speed, compared to peers, in primary school	2.35 (.99)	4.45 (.51)	<.001
Judgment of reading activity in primary school	2.45 (1.05)	4.15 (.75)	<.001
Number of books read per year for pleasure in primary school	2.25 (1.12)	3.90 (.97)	<.001
Difficulties learning orthography in primary school	2.05 (.95)	4.60 (.60)	<.001
Tendency to reverse letters or digits in primary school	2.75 (1.45)	4.45 (1.00)	<.001
Difficulties learning the names of people or places in primary school	4.00 (.86)	4.95 (.22)	<.001
Amount of work to complete in primary school, compared to peers	2.55 (1.00)	4.65 (.49)	<.001
Actual difficulties to read	4.50 (.61)	5.00 (.00)	<.001
Actual time spent to read per day	3.95 (1.10)	4.50 (.76)	<.05
Actual number of books read per year for pleasure	2.85 (1.31)	3.65 (1.27)	<.05
Actual reading speed, compared to peers	3.00 (1.12)	4.45 (.51)	<.001
Actual difficulties in writing without spelling mistakes	2.90 (1.17)	4.60 (.50)	<.001
Actual tendency to reverse letters or digits	3.80 (1.06)	4.80 (.52)	<.001
Actual difficulties in remembering names of people and places	3.60 (1.31)	4.60 (.75)	<.01

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Exposure to French language	1.00 (.00)	1.05 (.22)	ns
Exposure to English language	2.65 (.59)	2.60 (1.05)	ns
Frequency of listening to music in French language	1.35 (.81)	1.70 (1.03)	ns
Frequency of listening to music in English language	1.45 (.76)	1.00 (.00)	<.01
Frequency of listening to music in another language	3.00 (1.03)	2.65 (1.27)	ns
Frequency of reading in French language	1.05 (.22)	1.00 (.00)	ns
Frequency of reading in English language	1.85 (.81)	1.95 (1.19)	ns
Frequency of reading in another language	3.45 (.95)	3.35 (1.04)	ns
Frequency of watching videos in French language	1.05 (.22)	1.15 (.67)	ns
Frequency of watching videos in English language	1.65 (.67)	1.70 (1.03)	ns
Frequency of watching videos in another language	3.15 (.99)	2.85 (1.18)	ns
Frequency of playing video-games in French language	2.85 (1.35)	2.70 (1.34)	ns
Frequency of playing video-games in English language	3.10 (1.17)	3.30 (1.08)	ns
Frequency of playing video-games in another language	3.95 (.22)	3.85 (.49)	ns
Socio-economic status	3.87 (2.56)	3.37 (2.34)	ns

A26.3. French university students, both typical and dyslexic-readers: comparison of sub-groups.

Appendix-Table 36 page 358 presents the answers of both sub-groups of typical – namely written-TypFrUnivMatched (wTFUM) and oral-TypFrUnivMatched (oTFUM) – and dyslexic-readers – namely written-DysFrUniv (wDFU) and oral-DysFrUniv (oDFU) sub-groups, to the Adult Reading Habits Questionnaire, as well as the statistics comparing those sub-groups.

Appendix-Table 36. Questionnaire - French university students: comparison of the subgroups of typical and dyslexic-readers - Experiment 3.

Data	Mean (SD) wTFUM group	Mean (SD) oTFUM group	p-value	Mean (SD) wDFU group	Mean (SD) oDFU group	p-value
Attitude toward primary school	4.00 (.82)	4.00 (.91)	ns	3.14 (1.22)	3.08 (1.04)	ns
Difficulties learning to read in primary school	5.00 (.00)	4.85 (.38)	ns	3.00 (.82)	2.54 (.78)	ns
Help learning to read in primary school	5.00 (.00)	4.69 (.75)	ns	2.30 (1.11)	2.06 (1.47)	ns
Reading level, compared to peers, in primary school	4.29 (.76)	4.08 (.86)	ns	2.86 (1.22)	2.15 (.80)	ns
Reading speed, compared to peers, in primary school	4.43 (.54)	4.46 (.52)	ns	2.57 (1.13)	2.23 (.93)	ns
Judgment of reading activity in primary school	3.86 (.69)	4.31 (.75)	ns	2.57 (1.13)	2.39 (1.04)	ns
Number of books read per year for pleasure in primary school	3.57 (.98)	4.08 (.95)	ns	2.43 (1.13)	2.15 (1.14)	ns
Difficulties learning orthography in primary school	5.00 (.00)	4.39 (.65)	<.01	2.29 (.95)	1.92 (.95)	ns
Tendency to reverse letters or digits in primary school	4.43 (1.13)	4.46 (.97)	ns	2.71 (1.38)	2.77 (1.54)	ns
Difficulties learning the names of people or places in primary school	5.00 (.00)	4.92 (.28)	ns	4.00 (.82)	4.00 (.91)	ns
Amount of work to complete in primary school, compared to peers	4.86 (.38)	4.54 (.52)	ns	3.00 (1.16)	2.31 (.86)	ns
Actual difficulties to read	5.00 (.00)	5.00 (.00)	ns	4.71 (.49)	4.39 (.65)	ns
Actual time spent to read per day	4.43 (.54)	4.54 (.88)	ns	4.14 (.90)	3.85 (1.21)	ns
Actual number of books read per year for pleasure	3.57 (1.62)	3.69 (1.11)	ns	3.57 (1.13)	2.46 (1.27)	ns
Actual reading speed, compared to peers	4.43 (.54)	4.46 (.52)	ns	3.29 (1.25)	2.85 (1.07)	ns
Actual difficulties in writing without spelling mistakes	4.71 (.49)	4.54 (.52)	ns	3.00 (1.16)	2.85 (1.21)	ns
Actual tendency to reverse letters or digits	4.71 (.76)	4.85 (.38)	ns	3.71 (1.38)	3.85 (.90)	ns
Actual difficulties in remembering names of people and places	4.71 (.49)	4.54 (.88)	ns	3.57 (1.62)	3.62 (1.19)	ns

Data	Mean (SD) wTFUM group	Mean (SD) oTFUM group	p-value	Mean (SD) wDFU group	Mean (SD) oDFU group	p-value
Exposure to French language	1.00 (.00)	1.08 (.28)	ns	1.00 (.00)	1.00 (.00)	ns
Exposure to English language	2.71 (1.11)	2.54 (1.05)	ns	3.00 (.58)	2.46 (.52)	ns
Frequency of listening to music in French language	1.43 (.54)	1.85 (1.21)	ns	1.29 (.49)	1.39 (.96)	ns
Frequency of listening to music in English language	1.00 (.00)	1.00 (.00)	ns	1.43 (.54)	1.46 (.88)	ns
Frequency of listening to music in another language	2.71 (1.11)	2.62 (1.39)	ns	2.43 (.98)	3.31 (.95)	ns
Frequency of reading in French language	1.00 (.00)	1.00 (.00)	ns	1.14 (.38)	1.00 (.00)	ns
Frequency of reading in English language	2.00 (1.41)	1.92 (1.12)	ns	2.14 (.38)	1.69 (.95)	ns
Frequency of reading in another language	3.43 (1.13)	3.31 (1.03)	ns	3.43 (.98)	3.46 (.97)	ns
Frequency of watching videos in French language	1.00 (.00)	1.23 (.83)	ns	1.14 (.38)	1.00 (.00)	ns
Frequency of watching videos in English language	1.57 (1.13)	1.77 (1.01)	ns	1.86 (.69)	1.54 (.66)	ns
Frequency of watching videos in another language	3.00 (1.16)	2.77 (1.24)	ns	2.86 (1.07)	3.31 (.95)	ns
Frequency of playing video-games in French language	2.86 (1.35)	2.62 (1.39)	ns	3.43 (1.13)	2.54 (1.39)	ns
Frequency of playing video-games in English language	3.00 (1.41)	3.46 (.88)	ns	3.43 (1.13)	2.92 (1.19)	ns
Frequency of playing video-games in another language	4.71 (.76)	3.92 (.28)	ns	4.00 (.00)	3.92 (.28)	ns
Socio-economic status	3.85 (2.59)	3.12 (2.19)	ns	3.46 (2.32)	4.33 (2.69)	ns

Appendix 27. Experiment 3 – French university student groups – Complete results of the background tests.

A27.1. French typical-reader university students.

Appendix-Table 37 below presents the results of the sub-groups of French typical-reader university students of Experiment 3 to the different background tests.

Appendix-Table 37. Results of background tests - French typical-reader university students - Experiment 3.

Data	Mean (SD) oTFU group	Mean (SD) wTFU group	p-value
Dialang Level (out of 1,000)	568 (243)	578 (221)	ns
SRT	292 (32)	295 (36)	ns
CRT	445 (60)	465 (73)	ns

A27.2. French university students, both typical and dyslexic-readers.

Appendix-Table 38 below presents the pairings between the groups of typical and dyslexic-readers, according to the background tests of Experiment 3.

Appendix-Table 38. Results of background tests - French university students, both typical and dyslexic-readers - Experiment 3.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Dialang Level (out of 1,000)	491 (275)	541 (204)	ns
SRT	310 (37)	298 (36)	ns
CRT	475 (66)	477 (70)	ns

A27.3. French university students, comparison of the sub-groups of both typical and dyslexic-readers.

Appendix-Table 39 below presents the pairings between the four subgroups of typical (namely oral-TypFrUnivMatched (oTFUM) and written-TypFrUnivMatched (wTFUM) sub-groups) and dyslexic-readers (namely oral-DysFrUniv (oDFU) and written-DysFrUniv (wDFU) sub-groups).

Appendix-Table 39. Results of background tests - French university students, sub-groups of both typical and dyslexic-readers - Experiment 3.

Data	Mean (SD) oDFU sub-group	Mean (SD) wDFU sub-group	p-value	Mean (SD) oTFUM sub-group	Mean (SD) wTFUM sub-group	p-value
Dialang Level (out of 1,000)	537 (272)	404 (282)	ns	550 (220)	525 (186)	ns
SRT	309 (43)	311 (26)	ns	299 (33)	295 (42)	ns
CRT	479 (80)	468 (32)	ns	479 (73)	474 (69)	ns

Appendix 28. Experiment 3 – English stimuli for the task among French university students.

A28.1. Complete pairings between words and pseudowords.

Appendix-Table 40 below presents the complete pairing parameters of the 120 pairs of words and pseudowords of the task for French university students.

Appendix-Table 40. Complete pairing parameters for the 120 pairs of stimuli - French university students - Experiment 3.

Pairing parameters	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Number of			
Letters	5.54 (1.48)	5.57 (1.54)	ns
Phonemes	4.38 (1.43)	4.66 (1.69)	ns
Syllables	1.68 (.68)	1.68 (.70)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.04 (.69)	2.08 (.78)	ns	2.30 (.75)	2.26 (.80)	ns
Number of neighbours	5.15 (4.72)	4.98 (5.11)	ns	.83 (1.41)	1.22 (2.45)	ns
Mean frequency of neighbours	99.53 (212.54)	74.86 (148.29)	ns	39.73 (325.20)	40.09 (231.18)	ns
Phonological Neighbourhood						
PLD20	5.90 (2.83)	6.39 (2.92)	ns	5.77 (2.81)	6.22 (2.87)	ns
Number of neighbours	11.54 (11.85)	5.10 (5.49)	ns	3.92 (10.19)	1.24 (2.79)	ns
Mean frequency of neighbours	89.18 (160.37)	74.86 (148.29)	ns	19.96 (84.21)	66.43 (309.67)	ns
Orthographic Markedness						
Mean letter frequency	63590 (30328)	58834 (10753)	ns	62042 (17145)	62928 (17323)	ns
Minimum letter frequency	3935 (12335)	21986 (13621)	ns	11457 (15334)	16991 (19596)	ns
Mean bigram frequency	448 (801)	6447 (2655)	ns	5216 (2978)	5739 (3311)	ns
Minimum bigram frequency	11 (21)	1824 (1618)	ns	576 (1187)	793 (1614)	ns
Mean trigram frequency	403 (391)	2968 (2264)	ns	567 (735)	683 (1655)	ns
Minimum trigram frequency	37 (139)	202 (258)	ns	66 (207)	106 (295)	**<.05**

A28.2.Pairings between words and pseudowords of Group A.

Appendix-Table 41 below presents the pairings between words and pseudowords of the 40 pairs constituting Group A.

Appendix-Table 41. Complete pairing parameters for the 40 pairs of stimuli of Group A - French university students - Experiment 3.

Pairing parameters	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Number of			
Letters	5.48 (1.30)	5.68 (1.70)	ns
Phonemes	4.25 (1.30)	4.40 (1.48)	ns
Syllables	1.58 (.59)	1.60 (.63)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.04 (.59)	2.04 (.71)	ns	2.26 (.60)	2.22 (.71)	ns
Number of neighbours	4.53 (4.48)	4.88 (5.55)	ns	.65 (1.19)	1.00 (2.00)	ns
Mean frequency of neighbours	64.30 (129.41)	67.35 (99.06)	ns	12.90 (51.15)	100.36 (395.06)	ns
Phonological Neighbourhood						
PLD20	5.84 (2.82)	5.93 (2.65)	ns	5.67 (2.79)	5.78 (2.66)	ns
Number of neighbours	11.13 (10.33)	4.88 (5.55)	<.001	5.30 (13.83)	1.73 (3.64)	ns
Mean frequency of neighbours	89.36 (141.72)	67.35 (99.06)	ns	9.59 (35.08)	106.73 (398.70)	ns
Orthographic Markedness						
Mean letter frequency	70227 (30832)	36122 (56433)	<.01	64527 (18405)	63963 (20383)	ns
Minimum letter frequency	4053 (11350)	6867 (21991)	ns	11140 (15052)	17263 (19291)	ns
Mean bigram frequency	528 (776)	657 (1120)	ns	5514 (2669)	5552 (3553)	ns
Minimum bigram frequency	11 (21)	10 (15)	ns	486 (817)	812 (1657)	ns
Mean trigram frequency	377 (342)	348 (565)	ns	616 (853)	951 (2728)	ns
Minimum trigram frequency	27 (84)	28 (74)	ns	33 (110)	117 (390)	ns

A28.3. Pairings between words and pseudowords of Group B.

Appendix-Table 42 below presents the pairings between words and pseudowords of the 40 pairs constituting Group B.

Appendix-Table 42. Complete pairing parameters for the 40 pairs of stimuli of Group B - French university students - Experiment 3.

Pairing parameters	Words Mean (SD)	Pseudowords Mean (SD)	p-value
Number of			
Letters	5.65 (1.72)	5.53 (1.60)	ns
Phonemes	4.50 (1.49)	4.90 (1.84)	**<.01**
Syllables	1.70 (.72)	1.73 (.72)	ns

	Within-language parameters (in English)			Between-language parameters (in French)		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.07 (.79)	2.09 (.91)	ns	2.37 (.96)	2.33 (.98)	ns
Number of neighbours	5.95 (5.14)	5.48 (5.02)	ns	1.08 (1.67)	1.80 (3.41)	ns
Mean frequency of neighbours	79.05 (163.68)	79.29 (170.60)	ns	97.46 (560.86)	13.02 (33.52)	ns
Phonological Neighbourhood						
PLD20	5.95 (3.00)	6.84 (3.24)	<.001	5.92 (3.05)	6.70 (3.15)	<.01
Number of neighbours	12.80 (13.68)	5.83 (6.08)	<.001	3.78 (8.57)	1.00 (2.55)	<.05
Mean frequency of neighbours	70.41 (124.00)	79.29 (170.60)	ns	22.12 (99.64)	27.20 (120.71)	ns
Orthographic Markedness						
Mean letter frequency	60704 (30014)	26764 (33744)	<.001	59557 (16855)	62599 (16080)	ns
Minimum letter frequency	5705 (17140)	3924 (7876)	ns	11680 (16273)	14832 (16940)	ns
Mean bigram frequency	285 (394)	665 (1505)	ns	4860 (3052)	5785 (2904)	ns
Minimum bigram frequency	15 (25)	10 (17)	ns	730 (1372)	763 (1537)	ns
Mean trigram frequency	472 (432)	407 (408)	ns	497 (538)	562 (580)	ns
Minimum trigram frequency	63 (210)	36 (99)	ns	107 (277)	139 (300)	ns

A28.4.Pairings between words and pseudowords of Group C.

Appendix-Table 43 below presents the pairings between words and pseudowords of the 40 pairs constituting Group C.

Appendix-Table 43. Complete pairing parameters for the 40 pairs of stimuli of Group C - French university students - Experiment 3.

Pairing parameters	Words Mean (SD)	Pseudowords Mean (SD)	p-value
Number of			
Letters	5.50 (1.43)	5.50 (1.34)	ns
Phonemes	4.40 (1.53)	4.68 (1.73)	ns
Syllables	1.75 (.71)	1.73 (.75)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.02 (.70)	2.11 (.72)	ns	2.27 (.64)	2.25 (.69)	ns
Number of neighbours	4.98 (4.50)	4.60 (4.82)	ns	.75 (1.32)	.85 (1.48)	ns
Mean frequency of neighbours	155.23 (299.03)	77.95 (167.63)	**<.05**	8.82 (19.49)	6.88 (16.66)	ns
Phonological Neighbourhood						
PLD20	5.90 (2.72)	6.41 (2.82)	ns	5.73 (2.65)	6.18 (2.79)	ns
Number of neighbours	10.70 (11.49)	4.60 (4.82)	<.001	2.68 (6.95)	1.00 (1.90)	ns
Mean frequency of neighbours	107.77 (205.65)	77.95 (167.63)	ns	28.15 (101.46)	65.37 (340.33)	ns
Orthographic Markedness						
Mean letter frequency	59840 (29783)	17319 (13737)	<.001	62041 (16168)	62221 (15488)	ns
Minimum letter frequency	2046 (5897)	4178 (8760)	ns	11550 (15028)	18879 (22450)	<.05
Mean bigram frequency	530 (1077)	606 (1346)	ns	5274 (3223)	5878 (3513)	ns
Minimum bigram frequency	9 (17)	13 (35)	ns	511 (1309)	804 (1686)	ns
Mean trigram frequency	361 (395)	422 (547)	ns	588 (790)	537 (687)	ns
Minimum trigram frequency	22 (84)	94 (385)	ns	56 (196)	62 (138)	ns

A28.5. Pairings between words of Groups A and B.

Appendix-Table 44 below presents the pairings between the 40 words of Group A and the 40 words of Group B.

Appendix-Table 44. Complete pairing parameters words of Groups A and B - French university students - Experiment 3.

Pairing parameters	Words A Mean (SD)	Words B Mean (SD)	p-value
Number of			
Letters	5.48 (1.30)	5.65 (1.72)	ns
Phonemes	4.25 (1.30)	4.50 (1.49)	ns
Syllables	1.58 (.59)	1.70 (.72)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Words A Mean (SD)	**Words B** Mean (SD)	**p-value**	**Words A** Mean (SD)	**Words B** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.04 (.59)	2.07 (.79)	ns	2.31 (.83)	2.32 (.78)	ns
Number of neighbours	4.53 (4.48)	5.95 (5.14)	ns	.88 (1.44)	.85 (1.49)	ns
Mean frequency of neighbours	64.30 (129.41)	79.05 (163.68)	ns	14.99 (50.88)	95.37 (561.20)	ns
Phonological Neighbourhood						
PLD20	5.84 (2.82)	5.95 (3.00)	ns	6.37 (3.20)	5.22 (2.48)	<.05
Number of neighbours	11.13 (10.33)	12.80 (13.68)	ns	4.70 (13.38)	4.38 (9.31)	ns
Mean frequency of neighbours	89.36 (141.72)	70.41 (124.00)	ns	9.32 (34.68)	22.39 (99.74)	ns
Orthographic Markedness						
Mean letter frequency	70227 (30832)	60704 (30014)	ns	63345 (18226)	60739 (17316)	ns
Minimum letter frequency	4053 (11350)	5705 (17140)	ns	10802 (11894)	12019 (18690)	ns
Mean bigram frequency	528 (776)	285 (394)	ns	4993 (2689)	5382 (3058)	ns
Minimum bigram frequency	11 (21)	15 (25)	ns	614 (836)	602 (1372)	ns
Mean trigram frequency	377 (342)	472 (432)	ns	536 (540)	578 (856)	ns
Minimum trigram frequency	27 (83)	63 (210)	ns	64 (173)	77 (249)	ns

A28.6. Pairings between words of Groups A and C.

Appendix-Table 45 below presents the pairings between the 40 words of Group A and the 40 words of Group C.

Appendix-Table 45. Complete pairing parameters words of Groups A and C - French university students - Experiment 3.

Pairing parameters	Words A Mean (SD)	Words C Mean (SD)	p-value
Number of			
Letters	5.48 (1.30)	5.50 (1.43)	ns
Phonemes	4.25 (1.30)	4.40 (1.53)	ns
Syllables	1.58 (.59)	1.75 (.71)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Words A Mean (SD)	**Words C** Mean (SD)	**p-value**	**Words A** Mean (SD)	**Words C** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.04 (.59)	2.02 (.70)	ns	2.31 (.83)	2.27 (.64)	ns
Number of neighbours	4.53 (4.48)	4.98 (4.50)	ns	.88 (1.44)	.75 (1.32)	ns
Mean frequency of neighbours	64.30 (129.41)	155.23 (299.03)	ns	14.99 (50.88)	8.82 (19.48)	ns
Phonological Neighbourhood						
PLD20	5.84 (2.82)	5.90 (2.72)	ns	6.37 (3.20)	5.73 (2.65)	ns
Number of neighbours	11.13 (10.33)	10.70 (11.49)	ns	4.70 (13.38)	2.68 (6.95)	ns
Mean frequency of neighbours	89.36 (141.72)	107.76 (205.65)	ns	9.32 (34.68)	28.15 (101.46)	ns
Orthographic Markedness						
Mean letter frequency	70227 (30832)	59840 (29783)	ns	63345 (18226)	62041 (16168)	ns
Minimum letter frequency	4053 (11350)	2046 (5897)	ns	10802 (11894)	11550 (15028)	ns
Mean bigram frequency	528 (776)	530 (1077)	ns	4993 (2689)	5274 (3223)	ns
Minimum bigram frequency	11 (21)	9 (17)	ns	614 (836)	511 (1309)	ns
Mean trigram frequency	377 (342)	361 (395)	ns	536 (540)	588 (790)	ns
Minimum trigram frequency	27 (83)	22 (83)	ns	64 (173)	56 (196)	ns

A28.7. Pairings between words of Groups B and C.

Appendix-Table 46 below presents the pairings between the 40 words of Group B and the 40 words of Group C.

Appendix-Table 46. Complete pairing parameters words of Groups B and C - French university students - Experiment 3.

Pairing parameters	Words B Mean (SD)	Words C Mean (SD)	p-value
Number of			
Letters	5.65 (1.72)	5.50 (1.43)	ns
Phonemes	4.50 (1.49)	4.40 (1.53)	ns
Syllables	1.70 (.72)	1.75 (.71)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Words B Mean (SD)	**Words C** Mean (SD)	**p-value**	**Words B** Mean (SD)	**Words C** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.07 (.79)	2.02 (.70)	ns	2.32 (.78)	2.27 (.64)	ns
Number of neighbours	5.95 (5.14)	4.98 (4.50)	ns	.85 (1.49)	.75 (1.32)	ns
Mean frequency of neighbours	79.05 (163.68)	155.23 (299.03)	ns	95.37 (561.20)	8.82 (19.48)	ns
Phonological Neighbourhood						
PLD20	5.95 (3.00)	5.90 (2.72)	ns	5.22 (2.48)	5.73 (2.65)	ns
Number of neighbours	12.80 (13.68)	10.70 (11.49)	ns	4.38 (9.31)	2.68 (6.95)	ns
Mean frequency of neighbours	70.41 (124.00)	107.76 (205.65)	ns	22.39 (99.74)	28.15 (101.46)	ns
Orthographic Markedness						
Mean letter frequency	60704 (30014)	59840 (29783)	ns	60739 (17316)	62041 (16168)	ns
Minimum letter frequency	5705 (17140)	2046 (5897)	ns	12019 (18690)	11550 (15028)	ns
Mean bigram frequency	285 (394)	530 (1077)	ns	5382 (3058)	5274 (3223)	ns
Minimum bigram frequency	15 (25)	9 (17)	ns	602 (1372)	511 (1309)	ns
Mean trigram frequency	472 (432)	361 (395)	ns	578 (856)	588 (790)	ns
Minimum trigram frequency	63 (210)	22 (83)	ns	77 (249)	56 (196)	ns

A28.8. Pairings between pseudowords of Groups A and B.

Appendix-Table 47 below presents the pairings between the 40 pseudowords of Group A and the 40 pseudowords of Group B.

Appendix-Table 47. Complete pairing parameters pseudowords of Groups A and B - French university students - Experiment 3.

Pairing parameters	Pseudowords A Mean (SD)	Pseudowords B Mean (SD)	p-value
Number of			
Letters	5.68 (1.70)	5.53 (1.60)	ns
Phonemes	4.40 (1.48)	4.90 (1.84)	ns
Syllables	1.60 (.63)	1.73 (.72)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Pseudowords A Mean (SD)	**Pseudowords B** Mean (SD)	**p-value**	**Pseudowords A** Mean (SD)	**Pseudowords B** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.04 (.71)	2.09 (.91)	ns	2.22 (.71)	2.33 (.98)	ns
Number of neighbours	4.88 (5.55)	5.48 (5.02)	ns	1.00 (2.00)	1.80 (3.41)	ns
Mean frequency of neighbours	67.35 (99.06)	79.29 (170.60)	ns	100.36 (395.06)	13.02 (33.52)	ns
Phonological Neighbourhood						
PLD20	5.93 (2.65)	6.84 (3.24)	ns	5.78 (2.66)	6.70 (3.15)	ns
Number of neighbours	4.88 (5.55)	5.83 (6.08)	ns	1.73 (3.64)	1.00 (2.55)	ns
Mean frequency of neighbours	67.35 (99.06)	79.29 (170.60)	ns	106.73 (398.70)	27.20 (120.71)	ns
Orthographic Markedness						
Mean letter frequency	36122 (56433)	26764 (33744)	ns	63963 (20383)	62599 (16080)	ns
Minimum letter frequency	6867 (21991)	3924 (7876)	ns	17263 (19291)	14832 (16940)	ns
Mean bigram frequency	657 (1120)	665 (1505)	ns	5552 (3553)	5785 (2904)	ns
Minimum bigram frequency	10 (15)	10 (17)	ns	812 (1657)	763 (1537)	ns
Mean trigram frequency	348 (565)	407 (408)	ns	951 (2728)	562 (580)	ns
Minimum trigram frequency	28 (74)	36 (99)	ns	117 (390)	139 (300)	ns

A28.9. Pairings between pseudowords of Groups A and C.

Appendix-Table 48 below presents the pairings between the 40 pseudowords of Group A and the 40 pseudowords of Group C.

Appendix-Table 48. Complete pairing parameters pseudowords of Groups A and C - French university students - Experiment 3.

Pairing parameters	**Pseudowords A** Mean (SD)	**Pseudowords C** Mean (SD)	**p-value**
Number of			
Letters	5.68 (1.70)	5.50 (1.34)	ns
Phonemes	4.40 (1.48)	4.68 (1.73)	ns
Syllables	1.60 (.63)	1.73 (.75)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Pseudowords A Mean (SD)	**Pseudowords C** Mean (SD)	**p-value**	**Pseudowords A** Mean (SD)	**Pseudowords C** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.04 (.71)	2.11 (.72)	ns	2.22 (.71)	2.25 (.69)	ns
Number of neighbours	4.88 (5.55)	4.60 (4.82)	ns	1.00 (2.00)	.85 (1.48)	ns
Mean frequency of neighbours	67.35 (99.06)	77.95 (167.63)	ns	100.36 (395.06)	6.88 (16.66)	ns
Phonological Neighbourhood						
PLD20	5.93 (2.65)	6.41 (2.82)	ns	5.78 (2.66)	6.18 (2.79)	ns
Number of neighbours	4.88 (5.55)	4.60 (4.82)	ns	1.73 (3.64)	1.00 (1.90)	ns
Mean frequency of neighbours	67.35 (99.06)	77.95 (167.63)	ns	106.73 (398.70)	65.37 (340.33)	ns
Orthographic Markedness						
Mean letter frequency	36122 (56433)	17319 (13737)	<.05	63963 (20383)	62221 (15488)	ns
Minimum letter frequency	6867 (21991)	4178 (8760)	ns	17263 (19291)	18879 (22450)	ns
Mean bigram frequency	657 (1120)	606 (1346)	ns	5552 (3553)	5878 (3513)	ns
Minimum bigram frequency	10 (15)	13 (35)	ns	812 (1657)	804 (1686)	ns
Mean trigram frequency	348 (565)	422 (547)	ns	951 (2728)	537 (687)	ns
Minimum trigram frequency	28 (74)	94 (385)	ns	117 (390)	62 (138)	ns

A28.10.Pairings between pseudowords of Groups B and C.

Appendix-Table 49 below presents the pairings between the 40 pseudowords of Group B and the 40 pseudowords of Group C.

Appendix-Table 49. Complete pairing parameters pseudowords of Groups B and C - French university students - Experiment 3.

Pairing parameters	**Pseudowords B** Mean (SD)	**Pseudowords C** Mean (SD)	**p-value**
Number of			
Letters	5.53 (1.60)	5.50 (1.34)	ns
Phonemes	4.90 (1.84)	4.68 (1.73)	ns
Syllables	1.73 (.72)	1.73 (.75)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Pseudowords B Mean (SD)	**Pseudowords C** Mean (SD)	**p-value**	**Pseudowords B** Mean (SD)	**Pseudowords C** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.09 (.91)	2.11 (.72)	ns	2.33 (.98)	2.25 (.69)	ns
Number of neighbours	5.48 (5.02)	4.60 (4.82)	ns	1.80 (3.41)	.85 (1.48)	ns
Mean frequency of neighbours	79.29 (170.60)	77.95 (167.63)	ns	13.02 (33.52)	6.88 (16.66)	ns
Phonological Neighbourhood						
PLD20	6.84 (3.24)	6.41 (2.82)	ns	6.70 (3.15)	6.18 (2.79)	ns
Number of neighbours	5.83 (6.08)	4.60 (4.82)	ns	1.00 (2.55)	1.00 (1.90)	ns
Mean frequency of neighbours	79.29 (170.60)	77.95 (167.63)	ns	27.20 (120.71)	65.37 (340.33)	ns
Orthographic Markedness						
Mean letter frequency	26764 (33744)	17319 (13737)	ns	62599 (16080)	62221 (15488)	ns
Minimum letter frequency	3924 (7876)	4178 (8760)	ns	14832 (16940)	18879 (22450)	ns
Mean bigram frequency	665 (1505)	606 (1346)	ns	5785 (2904)	5878 (3513)	ns
Minimum bigram frequency	10 (17)	13 (35)	ns	763 (1537)	804 (1686)	ns
Mean trigram frequency	407 (408)	422 (547)	ns	562 (580)	537 (687)	ns
Minimum trigram frequency	36 (99)	94 (385)	ns	139 (300)	62 (138)	ns

A28.11.Complete lists of stimuli.

A31.11.1.Words.

Group A: afternoon, allowed, answer, become, better, child, crazy, draw, even, everyone, father, forget, further, great, homework, hundred, leave, meet, most, much, often, over, please, school, should, someone, sorry, start, street, take, teacher, thing, three, today, twenty, very, week, when, work, world.

Group B: again, always, anything, bedroom, brother, computer, diary, dream, ever, everything, forty, give, happy, help, horse, keep, listen, might, mother, need, only, pick, poor, really, send, sister, something, speak, stay, summer, talk, thank, think, tick, together, understand, welcome, white, workbook, wrong.

Group C: agree, amazing, away, century, could, down, easy, every, expensive, food, funny, good, holiday, house, learn, little, morning, movie, never, other, picture, quite, room, share, small, sometimes, spend, story, swim, task, there, thirty, tired, tomorrow, usually, weather, well, woman, workshop, year.

A31.11.2.Pseudowords.

Group A: aftercoad, allaved, arther, bebove, blaw, blen, catter, chird, endlyone, eran, henched, hoseworn, iper, jory, loke, mone, mult, peave, peet, prease, purry, schook, screet, shouth, smunty, sombore, spaky, speat, splee, stame, tasher, teether, tobey, torcher, turget, ulten, whing, woft, wook, wopse.

Group B: agive, atrays, atubling, buproom, cester, cormuner, deorly, dreak, droom, englything, fagerner, fick, fursy, gire, haddy, herp, hurse, ider, jeed, misher, mived, pide, poon, samper, selt, shonter, snank, soilpling, staw, suavy, tage, teep, thunk, twong, underchime, urly, wemhome, werebook, whime, witten.

Group C: abree, agey, ariming, courn, cunducy, dode, eary, elvenrive, ernsy, famiday, flend, gewer, goom, guman, houch, leath, mucture, plaf, provy, quide, rarning, rask, rivie, roon, shane, smicty, smull, sonetives, tenny, thire, tocarrew, tood, tored, tottle, twim, umually, uster, wortship, wounter, wull.

Appendix 29. Experiment 3 – French stimuli for the task among English university students.

A29.1. Complete pairings between words and pseudowords.

Appendix-Table 50 below presents the complete pairing parameters of the 120 pairs of words and pseudowords of the task for English university students.

Appendix-Table 50. Complete pairing parameters for the 120 pairs of stimuli - English university students - Experiment 3.

Pairing parameters	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Number of			
Letters	6.09 (1.41)	6.09 (1.41)	ns
Phonemes	4.41 (1.10)	4.58 (1.07)	ns
Syllables	1.76 (.57)	1.78 (.58)	ns

	Within-language parameters (in French)			**Between-language parameters (in English)**		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.95 (.50)	2.01 (.67)	ns	2.02 (.65)	2.11 (.79)	ns
Number of neighbours	2.84 (3.44)	2.12 (2.78)	ns	1.16 (2.86)	1.22 (2.47)	ns
Mean frequency of neighbours	69.23 (151.17)	106.78 (367.01)	ns	40.41 (203.12)	35.13 (180.10)	ns
Phonological Neighbourhood						
PLD20	1.41 (.55)	1.41 (.49)	ns	1.91 (.68)	1.90 (.60)	ns
Number of neighbours	16.02 (18.89)	12.12 (2.78)	ns	1.95 (5.84)	1.22 (2.47)	ns
Mean frequency of neighbours	75.89 (151.81)	106.78 (367.01)	ns	74.18 (294.28)	35.13 (181.10)	ns
Orthographic Markedness						
Mean letter frequency	66535 (12583)	66456 (11980)	ns	55748 (12774)	56717 (11586)	ns
Minimum letter frequency	21873 (16723)	23641 (17844)	ns	10132 (10012)	12774 (11245)	ns
Mean bigram frequency	4814 (1838)	4551 (1756)	ns	8171 (3647)	8558 (3549)	ns
Minimum bigram frequency	356 (854)	344 (889)	ns	959 (914)	1030 (793)	ns
Mean trigram frequency	1842 (1104)	1679 (1135)	ns	775 (528)	799 (522)	ns
Minimum trigram frequency	60 (171)	53 (168)	ns	13 (24)	16 (27)	ns

A29.2. Pairings between words and pseudowords of Group A.

Appendix-Table 51 below presents the pairings between words and pseudowords of the 40 pairs constituting Group A.

Appendix-Table 51. Complete pairing parameters for the 40 pairs of stimuli of Group A - French university students - Experiment 3.

Pairing parameters	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Number of			
Letters	5.93 (1.29)	5.93 (1.29)	ns
Phonemes	4.35 (1.10)	4.48 (1.11)	ns
Syllables	1.73 (.55)	1.75 (.54)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.96 (.50)	2.10 (.87)	ns	1.99 (.67)	2.20 (.95)	ns
Number of neighbours	2.95 (3.23)	2.25 (3.01)	<.05	1.18 (2.75)	1.30 (2.41)	ns
Mean frequency of neighbours	68.59 (123.20)	125.46 (461.42)	ns	27.12 (149.57)	35.05 (164.82)	ns
Phonological Neighbourhood						
PLD20	1.42 (.56)	.39 (.49)	<.001	1.89 (.67)	.79 (.58)	<.001
Number of neighbours	14.23 (15.98)	2.25 (3.01)	<.001	1.43 (3.57)	1.30 (2.41)	ns
Mean frequency of neighbours	64.00 (89.89)	125.46 (461.42)	ns	61.46 (206.50)	35.95 (164.82)	ns
Orthographic Markedness						
Mean letter frequency	64326 (13411)	65408 (13944)	ns	55270 (13918)	56940 (11278)	ns
Minimum letter frequency	20892(18056)	22199 (20450)	ns	9771 (11557)	12311 (11582)	ns
Mean bigram frequency	4507 (1727)	4305 (1594)	ns	8199 (3598)	8890 (3557)	ns
Minimum bigram frequency	240 (738)	145 (505)	ns	975 (1096)	964 (866)	ns
Mean trigram frequency	1827 (1202)	1700 (1230)	ns	767 (582)	855 (615)	ns
Minimum trigram frequency	59 (190)	51 (192)	ns	13 (25)	18 (24)	ns

A29.3.Pairings between words and pseudowords of Group B.

Appendix-Table 52 below presents the pairings between words and pseudowords of the 40 pairs constituting Group B.

Appendix-Table 52. Complete pairing parameters for the 40 pairs of stimuli of Group B – English university students - Experiment 3.

Pairing parameters	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Number of			
Letters	6.28 (1.45)	6.28 (1.45)	ns
Phonemes	4.50 (1.06)	4.75 (1.06)	**<.05**
Syllables	1.73 (.60)	1.78 (.66)	ns

	Within-language parameters (in French)			**Between-language parameters (in English)**		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.94 (.58)	2.01 (.58)	ns	2.10 (.66)	2.10 (.71)	ns
Number of neighbours	2.98 (3.53)	2.20 (3.11)	ns	1.18 (3.27)	1.45 (3.06)	ns
Mean frequency of neighbours	59.71 (118.20)	126.77 (381.21)	ns	68.18 (294.75)	24.29 (103.83)	ns
Phonological Neighbourhood						
PLD20	1.41 (.56)	.49 (.49)	<.001	1.98 (.64)	1.07 (.57)	<.001
Number of neighbours	16.68 (20.32)	2.20 (3.11)	<.001	2.23 (6.66)	1.45 (3.06)	ns
Mean frequency of neighbours	62.46 (94.30)	126.77 (381.21)	ns	105.58 (437.39)	24.29 (103.83)	ns
Orthographic Markedness						
Mean letter frequency	68429 (13199)	69209 (11892)	ns	56934 (12772)	58025 (12204)	ns
Minimum letter frequency	21910 (16090)	23122 (15969)	ns	10835 (9822)	11100 (9386)	ns
Mean bigram frequency	5009 (1790)	4989 (1839)	ns	8726 (4070)	8585 (3327)	ns
Minimum bigram frequency	347 (827)	441 (907)	ns	888 (723)	913 (661)	ns
Mean trigram frequency	1919 (1051)	1913 (1045)	ns	817 (461)	835 (476)	ns
Minimum trigram frequency	50 (102)	82 (210)	ns	9 (12)	16 (37)	ns

A29.4. Pairings between words and pseudowords of Group C.

Appendix-Table 53 below presents the pairings between words and pseudowords of the 40 pairs constituting Group C.

Appendix-Table 53. Complete pairing parameters for the 40 pairs of stimuli of Group C - English university students - Experiment 3.

Pairing parameters	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Number of			
Letters	6.08 (1.49)	6.08 (1.49)	ns
Phonemes	4.38 (1.17)	4.50 (1.04)	ns
Syllables	1.83 (.55)	1.83 (.55)	ns

	Within-language parameters (in French)			**Between-language parameters (in English)**		
	Words Mean (SD)	**Pseudowords** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.93 (.44)	1.92 (.50)	ns	1.96 (.64)	2.02 (.71)	ns
Number of neighbours	2.60 (3.64)	1.90 (2.17)	ns	1.13 (2.58)	.90 (1.82)	ns
Mean frequency of neighbours	79.39 (200.94)	68.10 (224.62)	ns	25.92 (124.33)	46.05 (248.76)	ns
Phonological Neighbourhood						
PLD20	1.38 (.54)	.34 (.50)	<.001	1.87 (.74)	.84 (.63)	<.001
Number of neighbours	17.15 (20.39)	1.90 (2.17)	<.001	2.20 (6.82)	.90 (1.82)	ns
Mean frequency of neighbours	101.20 (228.83)	68.10 (224.62)	ns	55.51 (169.61)	46.05 (248.76)	ns
Orthographic Markedness						
Mean letter frequency	66851 (10965)	64750 (9497)	ns	55039 (11785)	55185 (11369)	ns
Minimum letter frequency	22819 (16325)	25601 (17088)	ns	9790 (8663)	14909 (12484)	<.05
Mean bigram frequency	4927 (1992)	4359 (1786)	ns	7589 (3227)	8201 (3804)	ns
Minimum bigram frequency	421 (991)	446 (1128)	ns	1014 (902)	1212 (824)	ns
Mean trigram frequency	1781 (1075)	1424 (1097)	<.001	743 (545)	708 (462)	ns
Minimum trigram frequency	71 (205)	25 (61)	ns	17 (31)	14 (17)	ns

A29.5. Pairings between words of Groups A and B.

Appendix-Table 54 below presents the pairings between the 40 words of Group A and the 40 words of Group B.

Appendix-Table 54. Complete pairing parameters words of Groups A and B - English university students - Experiment 3.

Pairing parameters	Words A Mean (SD)	Words B Mean (SD)	p-value
Number of			
Letters	5.93 (1.29)	6.28 (1.45)	ns
Phonemes	4.35 (1.10)	4.50 (1.06)	ns
Syllables	1.73 (.55)	1.73 (.60)	ns

	Within-language parameters (in French)			**Between-language parameters (in English)**		
	Words A Mean (SD)	**Words B** Mean (SD)	**p-value**	**Words A** Mean (SD)	**Words B** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.96 (.50)	1.94 (.58)	ns	1.99 (.67)	2.10 (.66)	ns
Number of neighbours	2.95 (3.23)	2.98 (3.53)	ns	1.18 (2.75)	1.18 (3.27)	ns
Mean frequency of neighbours	68.59 (123.20)	59.71 (118.20)	ns	27.12 (149.57)	68.18 (294.75)	ns
Phonological Neighbourhood						
PLD20	1.42 (.56)	1.41 (.56)	ns	1.89 (.67)	1.98 (.64)	ns
Number of neighbours	14.23 (15.98)	16.68 (20.32)	ns	1.43 (3.57)	2.23 (6.66)	ns
Mean frequency of neighbours	64.00 (89.89)	62.46 (94.30)	ns	61.46 (206.50)	105.58 (437.39)	ns
Orthographic Markedness						
Mean letter frequency	64326 (13411)	68429 (13199)	ns	55270 (13918)	56934 (12772)	ns
Minimum letter frequency	20892(18056)	21910 (16090)	ns	9771 (11557)	10835 (9822)	ns
Mean bigram frequency	4507 (1727)	5009 (1790)	ns	8199 (3598)	8726 (4070)	ns
Minimum bigram frequency	240 (738)	347 (827)	ns	975 (1096)	888 (723)	ns
Mean trigram frequency	1827 (1202)	1919 (1051)	ns	767 (582)	817 (461)	ns
Minimum trigram frequency	59 (190)	50 (102)	ns	13 (25)	9 (12)	ns

A29.6. Pairings between words of Groups A and C.

Appendix-Table 55 below presents the pairings between the 40 words of Group A and the 40 words of Group C.

Appendix-Table 55. Complete pairing parameters words of Groups A and C - English university students - Experiment 3.

Pairing parameters	Words A Mean (SD)	Words C Mean (SD)	p-value
Number of			
Letters	5.93 (1.29)	6.08 (1.49)	ns
Phonemes	4.35 (1.10)	4.38 (1.17)	ns
Syllables	1.73 (.55)	1.83 (.55)	ns

	Within-language parameters (in French)			Between-language parameters (in English)		
	Words A Mean (SD)	**Words C** Mean (SD)	**p-value**	**Words A** Mean (SD)	**Words C** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.96 (.50)	1.93 (.44)	ns	1.99 (.67)	1.96 (.64)	ns
Number of neighbours	2.95 (3.23)	2.60 (3.64)	ns	1.18 (2.75)	1.13 (2.58)	ns
Mean frequency of neighbours	68.59 (123.20)	79.39 (200.94)	ns	27.12 (149.57)	25.92 (124.33)	ns
Phonological Neighbourhood						
PLD20	1.42 (.56)	1.38 (.54)	ns	1.89 (.67)	1.87 (.74)	ns
Number of neighbours	14.23 (15.98)	17.15 (20.39)	ns	1.43 (3.57)	2.20 (6.82)	ns
Mean frequency of neighbours	64.00 (89.89)	101.20 (228.83)	ns	61.46 (206.50)	55.51 (169.61)	ns
Orthographic Markedness						
Mean letter frequency	64326 (13411)	66851 (10965)	ns	55270 (13918)	55039 (11785)	ns
Minimum letter frequency	20892(18056)	22819 (16325)	ns	9771 (11557)	9790 (8663)	ns
Mean bigram frequency	4507 (1727)	4927 (1992)	ns	8199 (3598)	7589 (3227)	ns
Minimum bigram frequency	240 (738)	421 (991)	ns	975 (1096)	1014 (902)	ns
Mean trigram frequency	1827 (1202)	1781 (1075)	ns	767 (582)	743 (545)	ns
Minimum trigram frequency	59 (190)	71 (205)	ns	13 (25)	17 (31)	ns

A29.7. Pairings between words of Groups B and C.

Appendix-Table 56 below presents the pairings between the 40 words of Group B and the 40 words of Group C.

Appendix-Table 56. Complete pairing parameters words of Groups B and C - English university students - Experiment 3.

Pairing parameters	Words B Mean (SD)	Words C Mean (SD)	p-value
Number of			
Letters	6.28 (1.45)	6.08 (1.49)	ns
Phonemes	4.50 (1.06)	4.38 (1.17)	ns
Syllables	1.73 (.60)	1.83 (.55)	ns

	Within-language parameters (in French)			Between-language parameters (in English)		
	Words B Mean (SD)	Words C Mean (SD)	p-value	Words B Mean (SD)	Words C Mean (SD)	p-value
Orthographic Neighbourhood						
OLD20	1.94 (.58)	1.93 (.44)	ns	2.10 (.66)	1.96 (.64)	ns
Number of neighbours	2.98 (3.53)	2.60 (3.64)	ns	1.18 (3.27)	1.13 (2.58)	ns
Mean frequency of neighbours	59.71 (118.20)	79.39 (200.94)	ns	68.18 (294.75)	25.92 (124.33)	ns
Phonological Neighbourhood						
PLD20	1.41 (.56)	1.38 (.54)	ns	1.98 (.64)	1.87 (.74)	ns
Number of neighbours	16.68 (20.32)	17.15 (20.39)	ns	2.23 (6.66)	2.20 (6.82)	ns
Mean frequency of neighbours	62.46 (94.30)	101.20 (228.83)	ns	105.58 (437.39)	55.51 (169.61)	ns
Orthographic Markedness						
Mean letter frequency	68429 (13199)	66851 (10965)	ns	56934 (12772)	55039 (11785)	ns
Minimum letter frequency	21910 (16090)	22819 (16325)	ns	10835 (9822)	9790 (8663)	ns
Mean bigram frequency	5009 (1790)	4927 (1992)	ns	8726 (4070)	7589 (3227)	ns
Minimum bigram frequency	347 (827)	421 (991)	ns	888 (723)	1014 (902)	ns
Mean trigram frequency	1919 (1051)	1781 (1075)	ns	817 (461)	743 (545)	ns
Minimum trigram frequency	50 (102)	71 (205)	ns	9 (12)	17 (31)	ns

A29.8. Pairings between pseudowords of Groups A and B.

Appendix-Table 57 below presents the pairings between the 40 pseudowords of Group A and the 40 pseudowords of Group B.

Appendix-Table 57. Complete pairing parameters pseudowords of Groups A and B - English university students - Experiment 3.

Pairing parameters	**Pseudowords A** Mean (SD)	**Pseudowords B** Mean (SD)	**p-value**
Number of			
Letters	5.93 (1.29)	6.28 (1.45)	ns
Phonemes	4.48 (1.11)	4.75 (1.06)	ns
Syllables	1.75 (.54)	1.78 (.66)	ns

	Within-language parameters (in French)			**Between-language parameters (in English)**		
	Pseudowords A Mean (SD)	**Pseudowords B** Mean (SD)	**p-value**	**Pseudowords A** Mean (SD)	**Pseudowords B** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.10 (.87)	2.01 (.58)	ns	1.99 (.67)	2.10 (.71)	ns
Number of neighbours	2.25 (3.01)	2.20 (3.11)	ns	1.18 (2.75)	1.45 (3.06)	ns
Mean frequency of neighbours	125.46 (461.42)	126.77 (381.21)	ns	27.12 (149.57)	24.29 (103.83)	ns
Phonological Neighbourhood						
PLD20	.39 (.49)	.49 (.49)	ns	1.89 (.67)	1.07 (.57)	<.05
Number of neighbours	2.25 (3.01)	2.20 (3.11)	ns	1.43 (3.57)	1.45 (3.06)	ns
Mean frequency of neighbours	125.46 (461.42)	126.77 (381.21)	ns	61.46 (206.50)	24.29 (103.83)	ns
Orthographic Markedness						
Mean letter frequency	65408 (13944)	69209 (11892)	ns	55270 (13918)	58025 (12204)	ns
Minimum letter frequency	22199 (20450)	23122 (15969)	ns	9771 (11557)	11100 (9386)	ns
Mean bigram frequency	4305 (1594)	4989 (1839)	ns	8199 (3598)	8585 (3327)	ns
Minimum bigram frequency	145 (505)	441 (907)	ns	975 (1096)	913 (661)	ns
Mean trigram frequency	1700 (1230)	1913 (1045)	ns	767 (582)	835 (476)	ns
Minimum trigram frequency	51 (192)	82 (210)	ns	13 (25)	16 (37)	ns

A29.9. Pairings between pseudowords of Groups A and C.

Appendix-Table 58 below presents the pairings between the 40 pseudowords of Group A and the 40 pseudowords of Group C.

Appendix-Table 58. Complete pairing parameters pseudowords of Groups A and C - English university students - Experiment 3.

Pairing parameters	**Pseudowords A** Mean (SD)	**Pseudowords C** Mean (SD)	**p-value**
Number of			
Letters	5.93 (1.29)	6.08 (1.49)	ns
Phonemes	4.48 (1.11)	4.50 (1.04)	ns
Syllables	1.75 (.54)	1.83 (.55)	ns

	Within-language parameters (in French)			**Between-language parameters (in English)**		
	Pseudowords A Mean (SD)	**Pseudowords C** Mean (SD)	**p-value**	**Pseudowords A** Mean (SD)	**Pseudowords C** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.10 (.87)	1.92 (.50)	ns	1.99 (.67)	2.02 (.71)	ns
Number of neighbours	2.25 (3.01)	1.90 (2.17)	ns	1.18 (2.75)	.90 (1.82)	ns
Mean frequency of neighbours	125.46 (461.42)	68.10 (224.62)	ns	27.12 (149.57)	46.05 (248.76)	ns
Phonological Neighbourhood						
PLD20	.39 (.49)	.34 (.50)	ns	1.89 (.67)	.84 (.63)	ns
Number of neighbours	2.25 (3.01)	1.90 (2.17)	ns	1.43 (3.57)	.90 (1.82)	ns
Mean frequency of neighbours	125.46 (461.42)	68.10 (224.62)	ns	61.46 (206.50)	46.05 (248.76)	ns
Orthographic Markedness						
Mean letter frequency	65408 (13944)	64750 (9497)	ns	55270 (13918)	55185 (11369)	ns
Minimum letter frequency	22199 (20450)	25601 (17088)	ns	9771 (11557)	14909 (12484)	ns
Mean bigram frequency	4305 (1594)	4359 (1786)	ns	8199 (3598)	8201 (3804)	ns
Minimum bigram frequency	145 (505)	446 (1128)	ns	975 (1096)	1212 (824)	ns
Mean trigram frequency	1700 (1230)	1424 (1097)	ns	767 (582)	708 (462)	ns
Minimum trigram frequency	51 (192)	25 (61)	ns	13 (25)	14 (17)	ns

A29.10. Pairings between pseudowords of Groups B and C.

Appendix-Table 59 below presents the pairings between the 40 pseudowords of Group B and the 40 pseudowords of Group C.

Appendix-Table 59. Complete pairing parameters pseudowords of Groups B and C - French university students - Experiment 3.

Pairing parameters	Pseudowords B Mean (SD)	Pseudowords C Mean (SD)	p-value
Number of			
Letters	6.28 (1.45)	6.08 (1.49)	ns
Phonemes	4.75 (1.06)	4.50 (1.04)	ns
Syllables	1.78 (.66)	1.83 (.55)	ns

	Within-language parameters (in English)			**Between-language parameters (in French)**		
	Pseudowords B Mean (SD)	**Pseudowords C** Mean (SD)	**p-value**	**Pseudowords B** Mean (SD)	**Pseudowords C** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	2.01 (.58)	1.92 (.50)	ns	2.10 (.71)	2.02 (.71)	ns
Number of neighbours	2.20 (3.11)	1.90 (2.17)	ns	1.45 (3.06)	.90 (1.82)	ns
Mean frequency of neighbours	126.77 (381.21)	68.10 (224.62)	ns	24.29 (103.83)	46.05 (248.76)	ns
Phonological Neighbourhood						
PLD20	.49 (.49)	.34 (.50)	ns	1.07 (.57)	.84 (.63)	ns
Number of neighbours	2.20 (3.11)	1.90 (2.17)	ns	1.45 (3.06)	.90 (1.82)	ns
Mean frequency of neighbours	126.77 (381.21)	68.10 (224.62)	ns	24.29 (103.83)	46.05 (248.76)	ns
Orthographic Markedness						
Mean letter frequency	69209 (11892)	64750 (9497)	ns	58025 (12204)	55185 (11369)	ns
Minimum letter frequency	23122 (15969)	25601 (17088)	ns	11100 (9386)	14909 (12484)	ns
Mean bigram frequency	4989 (1839)	4359 (1786)	ns	8585 (3327)	8201 (3804)	ns
Minimum bigram frequency	441 (907)	446 (1128)	ns	913 (661)	1212 (824)	ns
Mean trigram frequency	1913 (1045)	1424 (1097)	<.05	835 (476)	708 (462)	ns
Minimum trigram frequency	82 (210)	25 (61)	ns	16 (37)	14 (17)	ns

A29.11.Complete lists of stimuli.

A32.11.1.Words.

Group A: alors, après, assis, autour, bientôt, bonne, chaque, chien, cœur, comprendre, contre, debout, dehors, déjà, depuis, école, fenêtre, garçon, heureux, hier, journée, libre, lorsque, maison, mari, monde, partout, petite, plutôt, pourquoi, propos, quelque, semaine, sœur, sortir, tellement, trois, vérité, vieux, voir.

Group B: ailleurs, amour, appeler, argent, attendre, aussitôt, beaucoup, boire, bonsoir, celui, chemin, combien, dernier, donc, dormir, endroit, entendre, fils, guerre, homme, laquelle, lumière, malgré, mettre, mieux, monsieur, parmi, pauvre, pourtant, prendre, prêt, quatre, rien, seulement, soir, sourire, toujours, venir, vite, voiture.

Group C: ainsi, année, assez, aucun, autant, besoin, bonheur, bord, cela, chacun, ciel, comme, compris, croire, demain, deux, doucement, enfin, femme, frère, jamais, laisser, lentement, longtemps, maintenant, mourir, parfois, partir, plaisir, porte, pouvoir, presque, quel, savoir, sinon, soleil, souvent, travers, voici, vraiment.

A32.11.2.Pseudowords.

Group A: agros, aiture, atars, barne, brague, brutet, candre, cortrandre, courquas, digre, duboit, essus, étune, fesâcle, gémité, grois, hoiteux, hourbée, laxique, leguis, lejors, maintôt, marde, mato, mier, noeur, parmiet, produs, quinque, rieux, roison, sernir, siveune, solite, trien, vançon, villament, voeur, vojà, vour.

Group B: aindeurs, assergne, attaler, avair, bonnuer, bonsoeur, bottre, brancoup, ceria, chevan, coisire, compion, cournant, doxe, enserper, entraut, erment, fien, fips, guelure, gunir, jorme, lerdier, mastré, nafaille, nieux, oissitir, pansi, plentre, poitre, pras, quople, soitament, suire, toir, tordir, touffoir, vierre, vome, vuroire.

Group C: aigun, airmi, ardée, assan, boupent, bussin, camplis, chaban, chamert, chaure, corge, corme, coulament, cuta, devoin, douf, draimant, ercin, folme, frainir, gauci, glète, guel, hamais, liel, lorstemps, monreur, oisant, pansir, parpuis, piantelant, plasque, pousoir, ramoir, rison, rord, soriel, soutir, tausser, tonsement.

Appendix 30. Experiment 4 – French university student groups - Demographic data of the sub-groups.

A30.1. French typical-reader university students.

Appendix-Table 60 below presents the demographic data of both sub-groups of French typical-reader university students – namely written-TypFrUniv (wTFU) and oral-Typ-FrUniv (oTFU), as well as the statistics comparing those sub-groups.

Appendix-Table 60. Demographic data - French typical-reader university students - Experiment 4.

Data	Mean (SD) oTFU group	Mean (SD) wTFU group	p-value
Age	26 (6)	27 (5)	ns
Gender (% of Female)	73	68	ns
Laterality (% of Right-handed)	95	81	<.01
Age of formal acquisition of English as an L2	10 (2)	9 (2)	ns
Socio-economic status	3.37 (2.24)	3.74 (2.27)	ns

A30.2. French university students, both typical and dyslexic-readers.

Appendix-Table 61 page 385 presents the demographic data of the sub-groups of French university students, both typical – namely written-TypFrUnivMatched (wTFUM) and oral-TypFrUnivMatched (oTFUM) sub-groups – and dyslexic-readers – namely written-DysFrUniv (wDFU) and oral-DysFrUniv (oDFU) sub-groups, as well as the statistics comparing those sub-groups.

Appendix-Table 61. Demographic data - French university students, both typical and dyslexic-readers - Experiment 4.

Data	Mean (SD) oDFU sub-group	Mean (SD) wDFU sub-group	p-value	Mean (SD) oTFUM sub-group	Mean (SD) wTFUM sub-group	p-value
Age	28 (4)	29 (4)	ns	27 (3)	29 (5)	ns
Gender (% of Female)	44	46	ns	67	82	ns
Laterality (% of Right-handed)	100	100	ns	100	100	ns
SRT	305 (52)	314 (21)	ns	284 (38)	302 (33)	ns
CRT	457 (44)	492 (79)	ns	444 (77)	485 (66)	ns

Appendix 31. Experiment 4 – French university students – pairings between typical and dyslexic-readers.

Appendix-Table 62 below presents the pairings between French typical and dyslexic-reader university students of Experiment 4.

Appendix-Table 62. Pairings between typical and dyslexic-readers - French university students - Experiment 4.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Age	28 (4)	28 (4)	ns
Gender (% of Female)	45	75	ns
Laterality (% of Right-handed)	100	100	ns
Order of presentation of modalities (% of WO)	45	45	ns
SRT	310 (37)	294 (36)	ns
CRT	476 (67)	467 (72)	ns

Appendix 32. Experiment 4 – French university student groups – Complete analysis of answers of the sub-groups to the Adult Reading Habits Questionnaire.

A32.1. French typical-reader university students.

Appendix-Table 63 below presents the answers of both sub-groups of French typical-reader university students – namely written-TypFrUnuv (wTFU) and oral-TypFrUniv (oTFU) sub-groups, to the Adult Reading Habits Questionnaire, as well as the statistics comparing those sub-groups. Most of questions were asked on a five-point Likert scale: the higher the value of the answer, the higher the ability to read for example. Conversely, the question concerning frequencies were asked on a four-point Likert scale: the lower the value of the answer, the higher the frequency of behaviour.

Appendix-Table 63. Questionnaire - French typical-reader university students - Experiment 4.

Data	Mean (SD) oTFU group	Mean (SD) wTFU group	p-value
Attitude toward primary school	3.93 (.89)	3.93 (1.00)	ns
Difficulties learning to read in primary school	4.74 (.56)	4.80 (.46)	ns
Help learning to read in primary school	4.37 (1.16)	4.45 (1.11)	ns
Reading level, compared to peers, in primary school	3.83 (.86)	3.98 (.80)	ns
Reading speed, compared to peers, in primary school	4.17 (.64)	4.35 (.48)	ns
Judgment of reading activity in primary school	3.69 (1.03)	3.93 (.92)	ns
Number of books read per year for pleasure in primary school	3.28 (1.20)	3.60 (1.30)	ns
Difficulties learning orthography in primary school	4.30 (.84)	4.25 (.87)	ns
Tendency to reverse letters or digits in primary school	4.59 (.74)	4.60 (.87)	ns
Difficulties learning the names of people or places in primary school	4.94 (.30)	4.95 (.22)	ns
Amount of work to complete in primary school, compared to peers	4.35 (.87)	4.45 (.82)	ns
Actual difficulties to read	4.91 (.29)	4.98 (.16)	ns
Actual time spent to read per day	4.04 (1.03)	4.15 (.92)	ns
Actual number of books read per year for pleasure	3.24 (1.26)	3.48 (1.18)	ns
Actual reading speed, compared to peers	4.07 (.72)	4.23 (.53)	ns
Actual difficulties in writing without spelling mistakes	4.61 (.49)	4.55 (.55)	ns
Actual tendency to reverse letters or digits	4.78 (.54)	4.90 (.30)	ns
Actual difficulties in remembering names of people and places	4.52 (.69)	4.33 (.94)	ns

Data	Mean (SD) oTFU group	Mean (SD) wTFU group	p-value
Exposure to French language	1.11 (.32)	1.03 (.16)	ns
Exposure to English language	2.59 (1.09)	2.45 (.85)	ns
Frequency of listening to music in French language	1.48 (.77)	1.75 (.95)	ns
Frequency of listening to music in English language	1.28 (.56)	1.35 (.74)	ns
Frequency of listening to music in another language	2.74 (1.15)	2.70 (1.07)	ns
Frequency of reading in French language	1.02 (.14)	1.05 (.22)	ns
Frequency of reading in English language	1.96 (1.03)	1.75 (.98)	ns
Frequency of reading in another language	3.33 (.95)	3.40 (.90)	ns
Frequency of watching videos in French language	1.11 (.46)	1.10 (.50)	ns
Frequency of watching videos in English language	1.70 (.92)	1.63 (.87)	ns
Frequency of watching videos in another language	3.20 (1.04)	3.18 (.93)	ns
Frequency of playing video-games in French language	2.57 (1.27)	2.48 (1.28)	ns
Frequency of playing video-games in English language	3.11 (1.18)	2.95 (1.18)	ns
Frequency of playing video-games in another language	3.89 (.42)	4.00 (.00)	ns
Socio-economic status	3.41 (2.26)	3.86 (2.38)	ns

A32.2. French university students, both typical and dyslexic-readers.

Appendix-Table 64 below presents the answers of both typical and dyslexic-readers to the Adult Reading Habits Questionnaire, as well as the statistics comparing those groups.

Appendix-Table 64. Questionnaire - French university students: comparison between typical and dyslexic-readers - Experiment 3.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Attitude toward primary school	3.10 (1.07)	4.05 (.83)	<.01
Difficulties learning to read in primary school	2.70 (.80)	4.95 (.22)	<.001
Help learning to read in primary school	2.14 (1.34)	4.80 (.62)	<.001
Reading level, compared to peers, in primary school	2.40 (1.00)	4.15 (.81)	<.001
Reading speed, compared to peers, in primary school	2.35 (.99)	4.45 (.51)	<.001
Judgment of reading activity in primary school	2.45 (1.05)	4.10 (.72)	<.001
Number of books read per year for pleasure in primary school	2.25 (1.12)	3.85 (.93)	<.001
Difficulties learning orthography in primary school	2.05 (.95)	4.65 (.49)	<.001
Tendency to reverse letters or digits in primary school	2.75 (1.45)	4.55 (.95)	<.001
Difficulties learning the names of people or places in primary school	4.00 (.86)	5.00 (.00)	<.001
Amount of work to complete in primary school, compared to peers	2.55 (1.00)	4.65 (.49)	<.001
Actual difficulties to read	4.50 (.61)	5.00 (.00)	<.001
Actual time spent to read per day	3.95 (1.10)	4.55 (.76)	<.05
Actual number of books read per year for pleasure	2.85 (1.31)	3.75 (1.29)	<.05
Actual reading speed, compared to peers	3.00 (1.12)	4.35 (.49)	<.001
Actual difficulties in writing without spelling mistakes	2.90 (1.17)	4.70 (.47)	<.001
Actual tendency to reverse letters or digits	3.80 (1.06)	4.80 (.52)	<.01
Actual difficulties in remembering names of people and places	3.60 (1.31)	4.55 (.76)	<.01

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Exposure to French language	1.00 (.00)	1.05 (.22)	ns
Exposure to English language	2.65 (.59)	2.50 (1.00)	ns
Frequency of listening to music in French language	1.35 (.81)	1.65 (1.04)	ns
Frequency of listening to music in English language	1.45 (.76)	1.00 (.00)	<.01
Frequency of listening to music in another language	3.00 (1.03)	2.55 (1.23)	ns
Frequency of reading in French language	1.05 (.22)	1.00 (.00)	ns
Frequency of reading in English language	1.85 (.81)	2.00 (1.26)	ns
Frequency of reading in another language	3.45 (.95)	3.35 (1.04)	ns
Frequency of watching videos in French language	1.05 (.22)	1.15 (.67)	ns
Frequency of watching videos in English language	1.65 (.67)	1.65 (.99)	ns
Frequency of watching videos in another language	3.15 (.99)	3.05 (1.15)	ns
Frequency of playing video-games in French language	2.85 (1.35)	2.65 (1.39)	ns
Frequency of playing video-games in English language	3.10 (1.17)	3.20 (1.15)	ns
Frequency of playing video-games in another language	3.95 (.22)	3.85 (.49)	ns
Socio-economic status	3.87 (2.56)	3.47 (2.38)	ns

A32.3. French university students, both typical and dyslexic-readers: comparison of sub-groups.

Appendix-Table 65 page 390 presents the answers of both sub-groups of typical (written-TypFrUnivMatched (wTFUM) and oral-TypFrUnivMatched (oTFUM sub-groups) and dyslexic-readers (written-DysFrUniv (wDFU) and oral-DysFrUniv (oDFU) sub-groups) to the Adult Reading Habits Questionnaire, as well as the statistics comparing those sub-groups.

Appendix-Table 65. Questionnaire - French university students: comparison of the subgroups of typical and dyslexic-readers - Experiment 3.

Data	Mean (SD) wTFMU group	Mean (SD) oTFUM group	p-value	Mean (SD) wDFU group	Mean (SD) oDFU group	p-value
Attitude toward primary school	4.20 (.79)	3.90 (.88)	ns	3.14 (1.22)	3.08 (1.04)	ns
Difficulties learning to read in primary school	4.90 (.32)	5.00 (.00)	ns	3.00 (.82)	2.54 (.78)	ns
Help learning to read in primary school	4.60 (.84)	5.00 (.00)	ns	2.30 (1.11)	2.06 (1.47)	ns
Reading level, compared to peers, in primary school	4.40 (.70)	3.90 (.88)	ns	2.86 (1.22)	2.15 (.80)	ns
Reading speed, compared to peers, in primary school	4.50 (.53)	4.40 (.52)	ns	2.57 (1.13)	2.23 (.93)	ns
Judgment of reading activity in primary school	4.30 (.82)	3.90 (.57)	ns	2.57 (1.13)	2.39 (1.04)	ns
Number of books read per year for pleasure in primary school	4.30 (.95)	3.40 (.70)	<.05	2.43 (1.13)	2.15 (1.14)	ns
Difficulties learning orthography in primary school	4.60 (.52)	4.70 (.48)	ns	2.29 (.95)	1.92 (.95)	ns
Tendency to reverse letters or digits in primary school	4.60 (.97)	4.50 (.97)	ns	2.71 (1.38)	2.77 (1.54)	ns
Difficulties learning the names of people or places in primary school	5.00 (.00)	5.00 (.00)	ns	4.00 (.82)	4.00 (.91)	ns
Amount of work to complete in primary school, compared to peers	4.70 (.48)	4.60 (.52)	ns	3.00 (1.16)	2.31 (.86)	ns
Actual difficulties to read	5.00 (.00)	5.00 (.00)	ns	4.71 (.49)	4.39 (.65)	ns
Actual time spent to read per day	4.50 (.97)	4.60 (.52)	ns	4.14 (.90)	3.85 (1.21)	ns
Actual number of books read per year for pleasure	4.10 (1.20)	3.40 (1.35)	ns	3.57 (1.13)	2.46 (1.27)	ns
Actual reading speed, compared to peers	4.50 (.53)	4.20 (.42)	ns	3.29 (1.25)	2.85 (1.07)	ns
Actual difficulties in writing without spelling mistakes	4.70 (.48)	4.70 (.48)	ns	3.00 (1.16)	2.85 (1.21)	ns
Actual tendency to reverse letters or digits	4.90 (.32)	4.70 (.68)	ns	3.71 (1.38)	3.85 (.90)	ns
Actual difficulties in remembering names of people and places	4.70 (.48)	4.40 (.97)	ns	3.57 (1.62)	3.62 (1.19)	ns

Data	Mean (SD) wTFUM group	Mean (SD) oTFUM group	p-value	Mean (SD) wDFU group	Mean (SD) oDFU group	p-value
Exposure to French language	1.00 (.00)	1.10 (.32)	ns	1.00 (.00)	1.00 (.00)	ns
Exposure to English language	2.70 (.95)	2.30 (1.06)	ns	3.00 (.58)	2.46 (.52)	ns
Frequency of listening to music in French language	1.90 (1.10)	1.40 (.97)	ns	1.29 (.49)	1.39 (.96)	ns
Frequency of listening to music in English language	1.00 (.00)	1.00 (.00)	ns	1.43 (.54)	1.46 (.88)	ns
Frequency of listening to music in another language	2.20 (1.14)	2.90 (1.29)	ns	2.43 (.98)	3.31 (.95)	ns
Frequency of reading in French language	1.00 (.00)	1.00 (.00)	ns	1.14 (.38)	1.00 (.00)	ns
Frequency of reading in English language	1.90 (1.20)	2.10 (1.37)	ns	2.14 (.38)	1.69 (.95)	ns
Frequency of reading in another language	3.30 (.82)	3.40 (1.27)	ns	3.43 (.98)	3.46 (.97)	ns
Frequency of watching videos in French language	1.00 (.00)	1.30 (.95)	ns	1.14 (.38)	1.00 (.00)	ns
Frequency of watching videos in English language	1.70 (1.06)	1.60 (.97)	ns	1.86 (.69)	1.54 (.66)	ns
Frequency of watching videos in another language	3.00 (1.05)	3.10 (1.29)	ns	2.86 (1.07)	3.31 (.95)	ns
Frequency of playing video-games in French language	2.90 (1.45)	2.40 (1.35)	ns	3.43 (1.13)	2.54 (1.39)	ns
Frequency of playing video-games in English language	3.60 (.84)	2.80 (1.32)	ns	3.43 (1.13)	2.92 (1.19)	ns
Frequency of playing video-games in another language	4.00 (.00)	3.70 (.68)	ns	4.00 (.00)	3.92 (.28)	ns
Socio-economic status	3.26 (2.30)	3.68 (2.46)	ns	3.46 (2.32)	4.33 (2.69)	ns

Appendix 33. Experiment 4 – French university student groups – Complete results of the background tests.

A33.1.French typical-reader university students.

Appendix-Table 66 below presents the results of the sub-groups of French typical-reader university students of Experiment 4 to the different background tests.

Appendix-Table 66. Results of background tests - French typical-reader university students - Experiment 4.

Data	Mean (SD) oTFU group	Mean (SD) wTFU group	p-value
Dialang Level (out of 1,000)	565 (219)	582 (244)	ns
SRT	290 (31)	298 (38)	ns
CRT	463 (107)	483 (125)	ns

A33.2.French university students, both typical and dyslexic-readers.

Appendix-Table 67 below presents the pairings between the groups of typical and dyslexic-readers, according to the background tests of Experiment 3.

Appendix-Table 67. Results of background tests - French university students, both typical and dyslexic-readers - Experiment 4.

Data	Mean (SD) Dyslexic-readers	Mean (SD) Typical-readers	p-value
Dialang Level (out of 1,000)	491 (275)	558 (201)	ns
SRT	310 (37)	293 (35)	ns
CRT	475 (66)	467 (72)	ns

A33.3. French university students, comparison of the sub-groups of both typical and dyslexic-readers.

Appendix-Table 68 below presents the pairings between the four subgroups of typical (namely oral-TypFrUnivMatched (oTFUM) and written-TypFrUnivMatched (wTFUM) sub-groups) and dyslexic-readers (namely oral-DysFrUniv (oDFU) and written-DysFrUniv (wDFU) sub-groups).

Appendix-Table 68. Results of background tests - French university students, sub-groups of both typical and dyslexic-readers - Experiment 4.

Data	Mean (SD) oDFU sub-group	Mean (SD) wDFU sub-group	p-value	Mean (SD) oTFUM sub-group	Mean (SD) wTFUM sub-group	p-value
Dialang Level (out of 1,000)	537 (272)	404 (282)	ns	584 (159)	531 (242)	ns
SRT	309 (43)	311 (26)	ns	288 (38)	299 (34)	ns
CRT	479 (80)	468 (32)	ns	444 (73)	489 (68)	ns

Appendix 34. Experiment 5 – French typical-reader university student group - Demographic data of the sub-groups.

Appendix-Table 69 below presents the demographic data of both sub-groups of French typical-reader university students – namely 50FU and 67FU, as well as the statistics comparing those sub-groups.

Appendix-Table 69. Demographic data - French typical-reader university students - Experiment 5.

Data	Mean (SD) 50FU group	Mean (SD) 67FU group	p-value
Age	20 (2)	21 (5)	ns
Gender (% of Female)	81	80	ns
Laterality (% of Right-handed)	84	80	ns
Age of formal acquisition of English as an L2	9 (2)	8 (3)	ns
Socio-economic status	3.30 (1.94)	3.58 (1.96)	ns

Appendix 35. Experiment 5 – English typical-reader university student group - Demographic data of the sub-groups.

Appendix-Table 70 below presents the demographic data of both sub-groups of English typical-reader university students – namely 50EU and 67EU, as well as the statistics comparing those sub-groups.

Appendix-Table 70. Demographic data - English typical-reader university students - Experiment 5.

Data	Mean (SD) 50EU group	Mean (SD) 67EU group	p-value
Age	20 (3)	20 (4)	ns
Gender (% of Female)	83	73	ns
Laterality (% of Right-handed)	93	90	ns
Socio-economic status	4.12 (2.26)	4.01 (1.80)	ns

Appendix 36. Experiment 5 – French university student group – Complete analysis of answers of the sub-groups to the Adult Reading Habits Questionnaire.

Appendix-Table 71 below presents the answers of both sub-groups of French typical-reader university students – namely 50FU and 67FU sub-groups, to the Adult Reading Habits Questionnaire, as well as the statistics comparing those sub-groups. Most of questions were asked on a five-point Likert scale: the higher the value of the answer, the higher the ability to read for example. Conversely, the question concerning frequencies were asked on a four-point Likert scale: the lower the value of the answer, the higher the frequency of behaviour.

Appendix-Table 71. Questionnaire - French typical-reader university students - Experiment 5.

Data	Mean (SD) 50FU sub-group	Mean (SD) 67FU sub-group	p-value
Attitude toward primary school	4.00 (.95)	4.09 (.81)	ns
Difficulties learning to read in primary school	4.65 (.65)	4.81 (.39)	ns
Help learning to read in primary school	4.21 (1.39)	4.63 (.90)	ns
Reading level, compared to peers, in primary school	3.70 (.83)	4.00 (.76)	ns
Reading speed, compared to peers, in primary school	4.07 (.83)	4.33 (.78)	ns
Judgment of reading activity in primary school	3.58 (1.01)	3.91 (.92)	ns
Number of books read per year for pleasure in primary school	3.26 (1.24)	3.49 (1.42)	ns
Difficulties learning orthography in primary school	4.30 (.91)	4.56 (.73)	ns
Tendency to reverse letters or digits in primary school	4.70 (.67)	4.56 (1.08)	ns
Difficulties learning the names of people or places in primary school	4.95 (.21)	4.95 (.21)	ns
Amount of work to complete in primary school, compared to peers	4.63 (.69)	4.61 (.58)	ns
Actual difficulties to read	4.93 (.34)	4.98 (.15)	ns
Actual time spent to read per day	3.35 (1.00)	3.67 (1.11)	ns
Actual number of books read per year for pleasure	2.81 (1.26)	3.07 (1.16)	ns
Actual reading speed, compared to peers	3.79 (.68)	4.05 (.53)	ns
Actual difficulties in writing without spelling mistakes	4.56 (.70)	4.67 (.52)	ns
Actual tendency to reverse letters or digits	4.84 (.53)	4.79 (.68)	ns
Actual difficulties in remembering names of people and places	4.56 (.59)	4.37 (1.02)	ns

Data	Mean (SD) 50FU sub-group	Mean (SD) 67FU sub-group	p-value
Exposure to French language	1.00 (.00)	1.02 (.15)	ns
Exposure to English language	2.37 (.54)	2.44 (.85)	ns
Frequency of listening to music in French language	1.28 (.63)	1.61 (.98)	ns
Frequency of listening to music in English language	1.16 (.53)	1.12 (.39)	ns
Frequency of listening to music in another language	3.38 (.85)	3.28 (1.20)	ns
Frequency of reading in French language	1.16 (.65)	1.19 (.59)	ns
Frequency of reading in English language	2.00 (.90)	1.88 (1.01)	ns
Frequency of reading in another language	3.84 (.49)	3.84 (.58)	ns
Frequency of watching videos in French language	1.12 (.50)	1.26 (.62)	ns
Frequency of watching videos in English language	1.72 (.73)	1.93 (1.01)	ns
Frequency of watching videos in another language	3.86 (.41)	3.65 (.84)	ns
Frequency of playing video-games in French language	2.65 (1.25)	3.12 (1.16)	ns
Frequency of playing video-games in English language	3.21 (1.08)	3.47 (.94)	ns
Frequency of playing video-games in another language	3.91 (.37)	3.98 (.15)	ns
Socio-economic status	3.30 (1.94)	3.58 (1.96)	ns

Appendix 37. Experiment 5 – English typical-reader university student group – Complete analysis of answers of the sub-groups to the translated version of the Adult Reading Habits Questionnaire.

Appendix-Table 72 below presents the answers of both sub-groups of English typical-reader university students – namely 50EU and 67EU, to the translated version of the Adult Reading Habits Questionnaire, as well as the statistics comparing those sub-groups. Most of questions were asked on a five-point Likert scale: the higher the value of the answer, the higher the ability to read for example. Conversely, the question concerning frequencies were asked on a four-point Likert scale: the lower the value of the answer, the higher the frequency of behaviour.

Appendix-Table 72. Questionnaire - English typical-reader university students - Experiment 5.

Data	Mean (SD) 50EU group	Mean (SD) 67EU group	p-value
Attitude toward primary school	4.50 (.63)	4.10 (1.03)	ns
Difficulties learning to read in primary school	2.77 (.50)	2.93 (.25)	ns
Help learning to read in primary school	4.37 (1.00)	4.53 (1.01)	ns
Reading level, compared to peers, in primary school	3.77 (.63)	4.20 (.93)	<.05
Reading speed, compared to peers, in primary school	3.13 (.73)	3.30 (.79)	ns
Judgment of reading activity in primary school	3.80 (.93)	3.73 (1.11)	ns
Number of books read per year for pleasure in primary school	4.03 (.85)	3.97 (1.13)	ns
Difficulties learning orthography in primary school	2.70 (.47)	2.80 (.48)	ns
Tendency to reverse letters or digits in primary school	3.83 (1.34)	4.27 (1.17)	ns
Difficulties learning the names of people or places in primary school	2.97 (.18)	3.00 (.00)	ns
Amount of work to complete in primary school, compared to peers	3.07 (.74)	3.37 (.81)	ns
Actual difficulties to read	2.93 (.25)	2.97 (.18)	ns
Actual time spent to read per day	3.50 (1.04)	3.73 (.91)	ns
Actual number of books read per year for pleasure	2.83 (1.05)	2.97 (1.27)	ns
Actual reading speed, compared to peers	2.87 (.63)	3.07 (.83)	ns
Actual difficulties in writing without spelling mistakes	2.57 (.50)	2.77 (.43)	ns
Actual tendency to reverse letters or digits	4.17 (1.32)	4.23 (1.38)	ns
Actual difficulties in remembering names of people and places	2.63 (.56)	2.73 (.52)	ns

Data	Mean (SD) 50EU group	Mean (SD) 67EU group	p-value
Exposure to French language	1.10 (.31)	1.07 (.25)	ns
Exposure to English language	4.07 (1.08)	4.40 (.93)	ns
Frequency of listening to music in French language	1.00 (.00)	1.00 (.00)	ns
Frequency of listening to music in English language	3.50 (.73)	3.53 (.82)	ns
Frequency of listening to music in another language	3.07 (1.16)	3.20 (.96)	ns
Frequency of reading in French language	1.03 (.19)	1.03 (.18)	ns
Frequency of reading in English language	3.45 (.78)	3.77 (.50)	ns
Frequency of reading in another language	3.54 (.96)	3.53 (.94)	ns
Frequency of watching videos in French language	1.00 (.00)	1.03 (.18)	ns
Frequency of watching videos in English language	3.59 (.68)	3.80 (.48)	ns
Frequency of watching videos in another language	3.39 (1.07)	3.47 (.82)	ns
Frequency of playing video-games in French language	2.72 (1.25)	2.10 (1.24)	ns
Frequency of playing video-games in English language	4.00 (.00)	3.93 (.37)	ns
Frequency of playing video-games in another language	3.96 (.19)	3.97 (.18)	ns
Socio-economic status	4.12 (2.26)	4.01 (1.80)	ns

Appendix 38. Experiment 5 – French typical-reader university student group – Complete results of the background tests.

Appendix-Table 73 below presents the results of both sub-groups of French typical-reader university students – namely 50FU and 67FU, to the different background tests, as well as the statistics comparing those sub-groups.

Appendix-Table 73. Results of background tests - French typical-reader university students - Experiment 5.

Data	Mean (SD) 50FU sub-group	Mean (SD) 67FU sub-group	p-value
Dialang Level (out of 1,000)	592 (124)	615 (211)	ns
Subtests from the ECLA16+ battery			
« Alouette » Reading time (in sec.)	97.44 (13.12)	91.51 (14.91)	ns
« Alouette » number of words correctly read (out of 265)	259.14 (4.40)	260.02 (3.31)	ns
« Pollueur » number of words correctly read in 1 min (out of 296)	184.40 (18.48)	190.60 (22.06)	ns
Word dictation score (out of 20)	14.37 (3.15)	15.51 (2.76)	ns
Word dictation time (in sec.)	86.60 (14.62)	84.69 (13.95)	ns
Pseudoword dictation score (out of 10)	7.07 (1.77)	8.56 (1.41)	<.05
Pseudoword dictation time (in sec.)	50.36 (8.62)	46.53 (7.33)	<.05
Initial phoneme deletion score (out of 10)	7.58 (2.87)	8.09 (2.68)	ns
Spoonerism score (out of 20)	17.21 (3.41)	17.42 (3.31)	ns
Symbol barrage score	21.00 (6.41)	21.36 (6.51)	ns
Picture naming time (in sec.)	15.31 (2.57)	14.30 (1.62)	<.05
Letter naming time (in sec.)	17.11 (3.07)	16.95 (2.63)	ns
Subtests from the EVALEC battery			
Number of pseudowords correctly read (out of 36)	32.74 (2.40)	32.07 (3.06)	ns
Pseudoword reading time (in ms.)	918.17 (168.83)	852.38 (168.92)	ns
Raven Progressive Matrix Score (out of 30)	24.07 (2.63)	24.87 (2.27)	ns
SRT	299.64 (49.95)	294.37 (21.59)	ns
CRT	471.88 (54.61)	451.55 (46.12)	ns

Appendix 39. Experiment 5 – English typical-reader university student group – Complete results of the background tests.

Appendix-Table 74 below presents the results of both sub-groups of English typical-reader university students – namely 50EU and 67EU, to the different background tests, as well as the statistics comparing those sub-groups.

Appendix-Table 74. Results of background tests - English typical-reader university students - Experiment 5.

Data	Mean (SD) 50EU sub-group	Mean (SD) 67EU sub-group	p-value
Dialang_Level (in English L1)	951 (53)	949 (66)	ns
Subtests from the YARC battery			
Text reading fluency 1 time (in sec.)	37 (5)	37 (8)	ns
Text reading fluency 2 time (in sec.)	46 (7)	46 (10)	ns
Subtests from the WIAT battery			
Word reading time (in sec.)	37 (9)	34 (8)	ns
Word reading score (out of 131)	127 (4)	128 (2)	ns
Pseudoword reading time (in sec.)	46 (11)	44 (9)	ns
Pseudoword reading score (out of 55)	51 (2)	50 (3)	ns
Word spelling score (out of 53)	45 (4)	47 (3)	ns
Subtests from the ECLA16+ battery			
Symbol barrage score	24.80 (6.81)	21.80 (5.93)	ns
Letter naming time (in sec.)	19.05 (4.37)	18.34 (4.17)	ns
Raven Progressive Matrix Score (out of 30)	23.03 (4.00)	22.97 (3.03)	ns
SRT	306.92 (29.15)	309.74 (30.42)	ns
CRT	474.03 (59.75)	450.51 (54.82)	ns

Appendix 40. Experiment 5 – Stimuli for the cross-modal repetition priming task.

A40.1. Complete pairings between words and pseudowords, and between cognate and non-cognate words.

Appendix-Table 75 below presents the complete pairing parameters of words and pseudowords, and between cognate and non-cognate words, of the cross-modal repetition priming task of Experiment 5.

Appendix-Table 75. Complete pairing parameters for the stimuli – All groups - Experiment 5.

Pairing parameters	**Cognate words** Mean (SD)	**Non-cognate words** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Number of						
Letters	5.98 (.70)	5.63 (.94)	**<.05**	5.81 (.85)	5.80 (.87)	ns
Phonemes	7.38 (1.33)	6.55 (1.38)	**<.01**	6.96 (1.42)	6.87 (1.52)	ns
Syllables	1.87 (.34)	1.53 (.50)	**<.001**	1.70 (.46)	1.73 (.50)	ns
	Within-language parameters (in English)					
	Cognate words Mean (SD)	**Non-cognate words** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	1.34 (.39)	1.19 (.49)	ns	1.26 (.45)	1.37 (.46)	ns
Number of neighbours	2.18 (2.00)	3.02 (2.59)	ns	2.61 (2.35)	2.24 (2.75)	ns
Mean frequency of neighbours	15.15 (40.85)	47.17 (133.86)	ns	31.40 (100.24)	40.57 (115.07)	ns
Phonological Neighbourhood						
PLD20	1.57 (.70)	1.33 (.74)	ns	1.45 (.73)	1.33 (.43)	ns
Number of neighbours	3.38 (6.11)	4.33 (4.59)	ns	3.87 (5.42)	3.00 (4.99)	ns
Mean frequency of neighbours	28.70 (66.35)	62.31 (138.64)	ns	45.87 (109.92)	46.46 (113.69)	ns
Orthographic Markedness						
Mean letter frequency	64296 (9292)	60634 (11024)	ns	62464 (10360)	60895 (11027)	ns
Minimum letter frequency	24642 (12950)	22183 (11656)	ns	23462 (12370)	23872 (13109)	ns
Mean bigram frequency	8605 (2469)	8275 (3193)	ns	8439 (2859)	7849 (2749)	ns
Minimum bigram frequency	1461 (956)	1385 (1193)	ns	1435 (1074)	1177 (1179)	ns
Mean trigram frequency	5145 (2437)	4755 (2648)	ns	4950 (2552)	4654 (2542)	ns
Minimum trigram frequency	131 (118)	142 (124)	ns	138 (121)	121 (160)	ns

	Between-language parameters (in French)					
	Cognate words Mean (SD)	**Non-cognate words** Mean (SD)	**p-value**	**Words** Mean (SD)	**Pseudowords** Mean (SD)	**p-value**
Orthographic Neighbourhood						
OLD20	.94 (.42)	1.26 (.51)	**<.001**	1.10 (.49)	1.20 (.44)	ns
Number of neighbours	1.10 (1.27)	.70 (1.59)	ns	.91 (1.45)	.76 (1.79)	ns
Mean frequency of neighbours	10.05 (14.72)	10.01 (38.34)	ns	10.11 (29.03)	10.65 (45.02)	ns
Phonological Neighbourhood						
PLD20	1.75 (.66)	1.58 (.73)	ns	1.66 (.70)	1.80 (.55)	ns
Number of neighbours	.54 (1.79)	2.28 (6.64)	ns	1.42 (4.42)	.56 (1.65)	ns
Mean frequency of neighbours	3.36 (15.77)	7.06 (26.94)	ns	5.25 (22.15)	8.25 (45.81)	ns
Orthographic Markedness						
Mean letter frequency	74992 (11637)	70325 (14428)	ns	72683 (13314)	73722 (15302)	ns
Minimum letter frequency	21388 (20784)	16656 (19254)	ns	19032 (20175)	21606 (20542)	ns
Mean bigram frequency	7607 (4039)	6365 (3294)	ns	6973 (3736)	7504 (3423)	ns
Minimum bigram frequency	1647 (2128)	489 (862)	**<.001**	1077 (1722)	756 (1134)	ns
Mean trigram frequency	935 (1113)	624 (787)	ns	776 (975)	865 (1036)	ns
Minimum trigram frequency	175 (370)	98 (347)	ns	137 (361)	105 (282)	ns

A40.2. Complete pairings between primes and targets (words) of the technical list A.

Appendix-Table 76 below presents the complete pairing parameters of primes and targets of the technical list A of the cross-modal repetition priming task of Experiment 5.

Appendix-Table 76. Complete pairing parameters – primes *vs.* targets list A – All groups - Experiment 5.

Pairing parameters	**Primes** Mean (SD)	**Targets** Mean (SD)	**p-value**
Number of			
Letters	5.80 (.89)	5.91 (.89)	ns
Phonemes	6.81 (1.42)	7.14 (1.54)	ns
Syllables	1.68 (.47)	1.73 (.49)	ns
Within-language parameters (in English)			
Orthographic Neighbourhood			
OLD20	1.21 (.49)	1.36 (.42)	ns
Number of neighbours	3.00 (2.62)	1.91 (1.74)	**<.01**
Mean frequency of neighbours	31.98 (109.94)	23.06 (104.97)	ns
Phonological Neighbourhood			
PLD20	1.30 (.60)	1.42 (.54)	ns
Number of neighbours	4.55 (6.35)	2.35 (2.17)	**<.01**
Mean frequency of neighbours	38.64 (87.14)	44.05 (111.06)	ns
Orthographic Markedness			
Mean letter frequency	60869 (13718)	62278 (11726)	ns
Minimum letter frequency	21864 (10856)	23621 (13248)	ns
Mean bigram frequency	8407 (3157)	8198 (2768)	ns
Minimum bigram frequency	1435 (1024)	1312 (978)	ns
Mean trigram frequency	4919 (2747)	4780 (2523)	ns
Minimum trigram frequency	131 (111)	129 (136)	ns
Between-language parameters (in French)			
Orthographic Neighbourhood			
OLD20	1.04 (.51)	1.17 (.46)	ns
Number of neighbours	1.09 (1.69)	.50 (.84)	**<.01**
Mean frequency of neighbours	12.34 (34.69)	5.59 (14.74)	ns
Phonological Neighbourhood			
PLD20	1.63 (.70)	1.86 (.55)	ns
Number of neighbours	1.88 (5.86)	1.18 (3.50)	ns
Mean frequency of neighbours	7.40 (26.74)	3.30 (11.24)	ns
Orthographic Markedness			
Mean letter frequency	71975 (16538)	71939 (15248)	ns
Minimum letter frequency	16587 (17078)	21038 (20656)	ns
Mean bigram frequency	6894 (3952)	6796 (3355)	ns
Minimum bigram frequency	988 (1765)	1083 (1524)	ns
Mean trigram frequency	845 (1109)	675 (661)	ns
Minimum trigram frequency	134 (329)	149 (381)	ns

A40.3. Complete pairings between primes and targets (words) of the technical list B.

Appendix-Table 77 below presents the complete pairing parameters of primes and targets of the technical list B of the cross-modal repetition priming task of Experiment 5.

Appendix-Table 77. Complete pairing parameters – primes *vs.* targets list B – All groups - Experiment 5.

Pairing parameters	Primes Mean (SD)	Targets Mean (SD)	p-value
Number of			
Letters	5.71 (.83)	5.91 (.89)	ns
Phonemes	6.85 (1.51)	7.14 (1.54)	ns
Syllables	1.70 (.46)	1.73 (.49)	ns
Within-language parameters (in English)			
Orthographic Neighbourhood			
OLD20	1.18 (.49)	1.36 (.42)	**<.05**
Number of neighbours	2.79 (2.58)	1.91 (1.74)	**<.05**
Mean frequency of neighbours	38.37 (117.43)	23.06 (104.97)	ns
Phonological Neighbourhood			
PLD20	1.39 (.76)	1.42 (.54)	ns
Number of neighbours	4.50 (6.37)	2.35 (2.17)	**<.01**
Mean frequency of neighbours	52.31 (87.14)	44.05 (111.06)	ns
Orthographic Markedness			
Mean letter frequency	60684 (14436)	62278 (11726)	ns
Minimum letter frequency	23441(13289)	23621 (13248)	ns
Mean bigram frequency	8260(3139)	8198 (2768)	ns
Minimum bigram frequency	1481 (1188)	1312 (978)	ns
Mean trigram frequency	4886 (2628)	4780 (2523)	ns
Minimum trigram frequency	147 (134)	129 (136)	ns
Between-language parameters (in French)			
Orthographic Neighbourhood			
OLD20	1.03 (.50)	1.17 (.46)	ns
Number of neighbours	1.09 (1.67)	.50 (.84)	**<.01**
Mean frequency of neighbours	11.59 (33.71)	5.59 (14.74)	ns
Phonological Neighbourhood			
PLD20	1.63 (.71)	1.86 (.55)	ns
Number of neighbours	1.18 (3.84)	1.18 (3.50)	ns
Mean frequency of neighbours	4.92 (22.76)	3.30 (11.24)	ns
Orthographic Markedness			
Mean letter frequency	71039 (18005)	71939 (15248)	ns
Minimum letter frequency	19323 (20158)	21038 (20656)	ns
Mean bigram frequency	6922 (4010)	6796 (3355)	ns
Minimum bigram frequency	1099 (1463)	1083 (1524)	ns
Mean trigram frequency	805 (1052)	675 (661)	ns
Minimum trigram frequency	124 (313)	149 (381)	ns

A40.4. Complete pairings between primes of both technical lists.

Appendix-Table 78 below presents the complete pairing parameters of primes of both technical lists of the cross-modal repetition priming task of Experiment 5.

Appendix-Table 78. Complete pairing parameters – primes both lists – All groups - Experiment 5.

Pairing parameters	Primes A Mean (SD)	Primes B Mean (SD)	p-value
Number of			
Letters	5.80 (.89)	5.71 (.83)	ns
Phonemes	6.81 (1.42)	6.85 (1.51)	ns
Syllables	1.68 (.47)	1.70 (.46)	ns
Within-language parameters (in English)			
Orthographic Neighbourhood			
OLD20	1.21 (.49)	1.18 (.49)	ns
Number of neighbours	3.00 (2.62)	2.79 (2.58)	ns
Mean frequency of neighbours	31.98 (109.94)	38.37 (117.43)	ns
Phonological Neighbourhood			
PLD20	1.30 (.60)	1.39 (.76)	ns
Number of neighbours	4.55 (6.35)	4.50 (6.37)	ns
Mean frequency of neighbours	38.64 (87.14)	52.31 (87.14)	ns
Orthographic Markedness			
Mean letter frequency	60869 (13718)	60684 (14436)	ns
Minimum letter frequency	21864 (10856)	23441(13289)	ns
Mean bigram frequency	8407 (3157)	8260(3139)	ns
Minimum bigram frequency	1435 (1024)	1481 (1188)	ns
Mean trigram frequency	4919 (2747)	4886 (2628)	ns
Minimum trigram frequency	131 (111)	147 (134)	ns
Between-language parameters (in French)			
Orthographic Neighbourhood			
OLD20	1.04 (.51)	1.17 (.46)	ns
Number of neighbours	1.09 (1.69)	.50 (.84)	ns
Mean frequency of neighbours	12.34 (34.69)	5.59 (14.74)	ns
Phonological Neighbourhood			
PLD20	1.63 (.70)	1.86 (.55)	ns
Number of neighbours	1.88 (5.86)	1.18 (3.50)	ns
Mean frequency of neighbours	7.40 (26.74)	3.30 (11.24)	ns
Orthographic Markedness			
Mean letter frequency	71975 (16538)	71939 (15248)	ns
Minimum letter frequency	16587 (17078)	21038 (20656)	ns
Mean bigram frequency	6894 (3952)	6796 (3355)	ns
Minimum bigram frequency	988 (1765)	1083 (1524)	ns
Mean trigram frequency	845 (1109)	675 (661)	ns
Minimum trigram frequency	134 (329)	149 (381)	ns

A40.5.Complete lists of stimuli.

A43.5.1.Words.

Primes: abroad, actress, airport, almost, aloud, angel, April, author, award, awesome, balloon, bean, beauty, blind, board, bottle, brave, breath, bubble, bucket, butter, canteen, captain, career, center, central, cheese, clear, coast, coffee, collect, column, concert, costume, courage, cousin, crew, current, daily, danger, dessert, double, dragon, drawing, empire, excuse, field, fifty, flour, forty, forward, fourth, Friday, giant, globe, health, heart, heaven, honey, horror, husband, ideal, indian, juice, legend, level, lively, local, lovely, lucky, member, minute, mirror, missing, mistake, moment, moose, mouse, murder, mystery, nation, native, nature, object, outfit, pizza, prison, proud, quarter, quote, reason, respect, safety, saint, sand, selfish, shine, shirt, shoulder, simple, sink, smoke, social, stone, stress, style, Sunday, super, survey, sweater, third, trade, truth, Tuesday, twelve, unfair, village, wind, witch, worse.

Targets: abroad, actress, airport, almost, aloud, angel, April, award, awesome, balloon, blind, bottle, brave, breath, bucket, canteen, captain, central, clear, coffee, collect, costume, cousin, daily, dessert, dragon, drawing, excuse, field, fifty, flour, forty, forward, fourth, Friday, giant, health, heart, heaven, horror, husband, indian, juice, legend, lively, lucky, member, minute, mirror, mistake, moose, mystery, nation, native, nature, object, outfit, pizza, prison, proud, quote, respect, safety, saint, selfish, shirt, shoulder, simple, social, stone, stress, style, super, sweater, third, Tuesday, twelve, unfair, witch, worse.

A43.5.2.Pseudowords.

Primes: afrol, agawn, airbert, alfost, anful, aproud, ateed, awesort, awplor, aybress, battoon, blith, boach, boafty, bopple, borrent, boudage, brare, brooth, buggle, candoon, captism, catear, cistral, coamin, codpee, collipe, confirt, coost, costown, cosual, cred, cubter, custer, deapon, decket, dessove, dofly, dourth, empone, exbuse, falward, fiece, fimbly, flewing, foxty, frayon, fushy, glome, greae, heafed, heaks, hoose, horpy, hotey, hounen, hurtor, huslant, iroal, juide, jullage, lodel, megend, mippor, mistyle, mobber, molent, mouch, naroon, natake, natose, objace, onsiad, outdot, plinay, possing, pramon, pumple, puner, punnay, puzzo, quoke, rancer, ranute, reslern, rin, roudle, rumder, saste, shielder, shint, shird, silfish, sint, sipial, sittery, smanter, smelve, smike, snird, speese, spoud, spour, stosh, struss, stybe, sumrey, sunety, tink, topal, toshly, traff, trith, tuneday, unfept, whooter, wiand, wimed, worns, yond.

Targets: afrol, agawn, airbert, alfost, anful, aproud, ateed, awesort, aybress, battoon, blith, bopple, brare, brooth, candoon, captism, cistral, coamin, codpee, collipe, costown, decket, dessove, dofly, dourth, exbuse, falward, fiece, fimbly, flewing, foxty, frayon, fushy, grear, heafed, heaks, hoose, horpy, hounen, hurtor, huslant, juide, megend, mipport, mistyle, mobber, naroon, natake, natose, objace, onsiad, outdot, plinay, pramon, pumple, puner, puzzo, quoke, ranute, reslern, saste, shielder, shird, silfish, sipial, sittery, smelve, snird, spoud, spour, stosh, struss, stybe, sunety, tuneday, unfept, whooter, wiand, wimed, worns.