Vocabulary and Lexical Development in Children: The Role of Learning Modality and Socioeconomic Status

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Vocabulaire et développement lexical chez les enfants : le rôle de la modalité d'apprentissage et du statut socio-économique

Travail de thèse présenté par

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pour l'obtention du titre de
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There are so many people, especially among our pals, who imagine that words are nothing. On the contrary, don't you think, it's as interesting and as difficult to say a thing well as to paint a thing. There's the art of lines and colors, but there's the art of words that will last just the same.

Vincent Van Gogh - Letter to Émile Bernard

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Abstract - English

During childhood, learning new words primarily occurs through oral exposure. However, literacy instruction introduces words in print, meaning reading becomes a significant source of vocabulary acquisition. However, not all children have the opportunity to engage in reading or to be exposed to varied vocabulary to the same extent, given their socioeconomic backgrounds. These differences in resources can lead to disparities in vocabulary that have a long-lasting impact on life.

In this dissertation, we focus on understanding children's vocabulary and their word-learning processes. First, we study the impact of socioeconomic background on children's vocabulary. Then, we crucially examine the role of learning modality in children who have almost finished literacy acquisition as they reach the end of primary school. Thus, three main research objectives guided the studies presented in this thesis: (1) To examine whether socioeconomic status impacts the two dimensions of vocabulary knowledge (breadth and depth) differently. (2) To investigate how oral and written learning modalities contribute to word-learning trajectories, from initial lexical configuration to later lexicalization. (3) To characterize how orthographic, phonological and semantic representations evolve over time and across learning modalities. These objectives were addressed through three experimental studies.

In Study 1, we examined the relationship between vocabulary breadth and depth, and socioeconomic status. Three points were considered. First, previous research consistently reports differences in vocabulary size across socioeconomic groups. Second, vocabulary knowledge varies in both extent and type. This distinction means there is a difference between vocabulary breadth, which refers to the number of words one knows, and vocabulary depth, which refers to detailed knowledge of words and the interconnection between. This implies that one can have partial or incomplete knowledge of a word, ignoring its contextual or figurative

meanings, for example. Furthermore, each component has been observed to contribute differently to reading scores.

Third, most studies examining socioeconomic status differences in vocabulary rely on measures that primarily assess vocabulary breadth, such as standardized tests of word knowledge. Consequently, the conclusions drawn from such studies may be limited to vocabulary breadth; much less is known about whether socioeconomic status affects vocabulary depth. It is plausible that differences in vocabulary exposure influence not only the number of words children know but also the quality of their lexical representations.

In Study 1, we present evidence that socioeconomic status significantly impacts both the breadth and depth of vocabulary. We also found that the impact of socioeconomic status on vocabulary depth can be more evident depending on the tasks used. These findings suggest the importance of considering both aspects of vocabulary and paying attention to the measures used when addressing children's vocabulary. Failing to consider children's contexts may result in overlooking their vocabulary knowledge.

One possible explanation for the extended impact of socioeconomic status is that children from low-socioeconomic status, who often have limited exposure to vocabulary, may have fewer opportunities to strengthen semantic relationships in their existing vocabulary, reducing not only the quantity of words with which they are familiar, but also the depth of their vocabulary. One reasonable question that may arise is under what conditions children acquire high-quality lexical knowledge that contributes to the depth of their vocabulary, making it well-interconnected and useful for comprehension and ongoing learning. Of myriad possibilities, we examined the impact of modality on the integration of lexical representations over time as a first step in word learning.

In Studies 2 and 3, we investigated how words that were learned through oral and written modalities were integrated into the lexicon over time. We considered the key theoretical

distinction between lexical configuration and lexicalization. Lexical configuration refers to the general knowledge of a word, such as the form that might emerge after the initial encounter with the word, while lexicalization refers to when a novel word becomes integrated into the lexicon and exhibits lexical effects over time, including faster recognition and lexical competition against other words.

To examine these processes, children were trained on real words under different learning conditions while exposure modality was systematically controlled for. We assessed their knowledge of the newly learned words immediately after training to capture lexical configuration and again one week later to evaluate lexicalization. This approach allowed us to track the development of orthographic, phonological, and semantic representations over time.

Study 2 showed that modality can impact the integration of word representations (i.e., orthography, phonology, and semantics). Specifically, we found that learning through written material facilitated acquisition of a word's form, while learning through speech produced stronger evidence of semantic integration after one week. Study 3 demonstrated that orthographic exposure alone produced learning outcomes comparable to those observed following sequential phonological and orthographic exposure. In other words, prior exposure to the phonological form of a word did not substantially enhance the acquisition of word representations.

Taken together, these findings highlight the importance of considering not only the quantity of vocabulary, but also the quality of lexical representations, as well as the modality in which children encounter and learn words.

Résumé - Français

Pendant l'enfance, l'apprentissage de nouveaux mots se fait principalement par exposition orale. Cependant, l'apprentissage de la lecture fait découvrir de nouveaux mots sous forme écrite, ce qui fait de la lecture une source importante d'acquisition du vocabulaire. Or, tous les enfants n'ont pas la même possibilité de s'adonner à la lecture ou d'être exposés à un vocabulaire varié, en raison de leur milieu socio-économique. Ces disparités peuvent entraîner des écarts de vocabulaire qui ont un impact durable sur la vie.

Dans ce travail, nous visons à mieux comprendre le vocabulaire des enfants et les processus d'apprentissage des mots. Tout d'abord, nous étudions l'impact du milieu socio-économique sur le vocabulaire des enfants. Ensuite, nous examinons plus particulièrement le rôle de la modalité d'apprentissage chez les enfants qui ont presque achevé leur apprentissage de la lecture et de l'écriture à la fin de l'école primaire. Ainsi, trois grands objectifs de recherche ont guidé les études présentées dans cette thèse : (1) Examiner si le niveau socio-économique a un impact différent sur deux dimensions du vocabulaire (l'étendue et la profondeur). (2) Étudier comment les modalités d'apprentissage oral et écrit contribuent aux trajectoires d'apprentissage des mots, dès la configuration lexicale initiale jusqu'à la lexicalisation. (3) Caractériser comment les représentations orthographiques, phonologiques et sémantiques évoluent au fil du temps et selon les modalités d'apprentissage. Ces objectifs ont été abordés à travers trois études expérimentales.

Dans l'étude 1, nous avons examiné la relation entre l'étendue et la profondeur du vocabulaire et le niveau socio-économique. Trois aspects ont été pris en compte. Premièrement, les recherches antérieures font systématiquement état de différences dans la taille du vocabulaire entre les groupes socio-économiques. Deuxièmement, la connaissance du vocabulaire varie tant en termes d'étendue que de la profondeur. Cette distinction signifie qu'il existe une différence entre le nombre de mots que l'on connaît (étendue), et la connaissance

détaillée de la signification des mots et les relations entre les mots (profondeur). Cela implique qu'on peut avoir une connaissance partielle ou incomplète d'un mot, en ignorant par exemple ses significations contextuelles ou figuratives. De plus, il a été observé que chaque composante contribue différemment aux résultats en lecture.

Troisièmement, la plupart des études examinant les différences de statut socio-économique en matière de vocabulaire s'appuient sur des mesures qui évaluent principalement l'étendue du vocabulaire, telles que les tests standardisés de reconnaissance des mots. Par conséquent, les conclusions tirées de ces études peuvent se limiter à l'étendue du vocabulaire ; on en sait beaucoup moins sur la question de l'influence du statut socio-économique sur la profondeur du vocabulaire. Il est plausible que les différences d'exposition au vocabulaire influencent non seulement le nombre de mots que les enfants connaissent, mais aussi la qualité de leurs représentations lexicales.

Dans la première étude, nous présentons des données qui montrent que le statut socio-économique a une incidence significative tant sur l'étendue que sur la profondeur du vocabulaire. Nous avons également constaté que l'impact du statut socio-économique sur la profondeur devient plus évident en fonction des tâches utilisées. Ces résultats soulignent l'importance de prendre en compte ces deux aspects du vocabulaire et d'accorder une attention particulière aux mesures utilisées lorsqu'on évalue le vocabulaire des enfants. Ne pas tenir compte du contexte dans lequel évoluent les enfants peut conduire à sous-estimer leurs connaissances lexicales.

Une explication possible de l'impact élargi du statut socio-économique est que les enfants issus de milieux socio-économiques défavorisés, qui sont souvent peu exposés au vocabulaire, peuvent avoir moins d'occasions de renforcer les relations sémantiques au sein de leur vocabulaire existant, ce qui réduit non seulement la quantité de mots qu'ils connaissent, mais aussi la profondeur de leur vocabulaire. Une question pertinente qui peut se poser est de savoir

dans quelles conditions les enfants acquièrent des connaissances lexicales de haute qualité qui contribuent à la richesse de leur vocabulaire, le rendant bien interconnecté et utile pour la compréhension et l'apprentissage continu. Parmi une multitude de possibilités, nous avons examiné l'impact de la modalité sur l'intégration des représentations lexicales au fil du temps comme première étape de l'apprentissage des mots.

Dans les études 2 et 3, nous avons examiné comment les mots appris par voie orale et écrite s'intégraient au lexique au fil du temps. Nous avons pris en considère la distinction théorique entre la configuration lexicale et la lexicalisation. La configuration lexicale fait référence à la connaissance générale d'un mot, telle que la forme qui peut émerger après la première rencontre avec le mot, tandis que la lexicalisation fait référence à l'intégration du nouveau mot dans lexique, produisant des effets lexicaux au fil du temps, notamment une reconnaissance plus rapide et une compétition lexicale avec d'autres mots.

Pour examiner ces processus, les enfants ont appris des mots réels dans différentes conditions d'apprentissage, la modalité d'exposition étant systématiquement contrôlée. Nous avons évalué leur connaissance des mots nouvellement appris immédiatement après l'apprentissage afin de saisir la configuration lexicale, puis à nouveau une semaine plus tard pour évaluer la lexicalisation. Cette approche nous a permis de suivre le développement des représentations orthographiques, phonologiques et sémantiques au fil du temps.

L'étude 2 a montré que la modalité peut influencer l'intégration des représentations lexicales (c'est-à-dire l'orthographe, la phonologie et la sémantique). Plus précisément, nous avons constaté que l'apprentissage à partir de supports écrits facilitait l'acquisition de la forme d'un mot, tandis que l'apprentissage oral semblait favoriser davantage l'intégration sémantique après une semaine. L'étude 3 a démontré que l'exposition orthographique seule produisait des résultats d'apprentissage comparables à ceux observés après une exposition séquentielle à la phonologie et à l'orthographe. En d'autres termes, une exposition préalable à la forme

phonologique d'un mot n'améliorait pas de manière significative l'acquisition des représentations lexicales.

Dans l'ensemble, ces résultats soulignent l'importance de prendre en compte non seulement la quantité de vocabulaire, mais aussi la qualité des représentations lexicales, ainsi que la modalité par laquelle les enfants rencontrent et apprennent les mots.

Resumen - Castellano

Durante la infancia, aprender nuevas palabras se lleva a cabo principalmente mediante exposición oral. Sin embargo, aprender a leer introduce nuevas palabras en forma escrita, lo que convierte la lectura en una fuente importante de adquisición de vocabulario. Sin embargo, no todos los niños tienen la misma oportunidad de leer o de estar expuestos a una variedad de vocabulario, debido a su entorno socioeconómico. Estas disparidades pueden provocar brechas de vocabulario que tienen un impacto duradero en la vida.

En este trabajo, nuestro objetivo es comprender mejor el vocabulario y el proceso de aprendizaje de palabras de los niños. Primero, estudiamos el impacto del entorno socioeconómico y luego examinamos más específicamente el papel de la modalidad de aprendizaje en niños que casi han completado su aprendizaje de la lectura ya que están al final de la escuela primaria. Así, tres objetivos principales de investigación han guiado los estudios presentados en esta tesis: (1) Examinar si el nivel socioeconómico tiene un impacto diferente en dos dimensiones del vocabulario (amplitud y profundidad). (2) Estudiar cómo las modalidades de aprendizaje oral y escrita contribuyen a las trayectorias de aprendizaje de palabras, desde la configuración léxica inicial hasta la lexicalización. (3) Caracterizar cómo evolucionan las representaciones ortográficas, fonológicas y semánticas a lo largo del tiempo y según las modalidades de aprendizaje. Estos objetivos se han abordado mediante tres estudios experimentales.

En el Estudio 1, examinamos la relación entre la amplitud y profundidad del vocabulario y el nivel socioeconómico. Se tuvieron en cuenta tres aspectos. En primer lugar, investigaciones previas informan de forma consistente diferencias en el tamaño del vocabulario entre grupos socioeconómicos. En segundo lugar, el conocimiento del vocabulario varía tanto en amplitud como en detalle. Esta distinción implica que existe una diferencia entre la amplitud, que se refiere al número de palabras que se conocen, y la profundidad del vocabulario, que se refiere

al conocimiento detallado del significado de las palabras. Esto implica que se puede tener un conocimiento parcial o incompleto de una palabra, ignorando, por ejemplo, sus significados contextuales o figurados. Además, se ha observado que cada componente contribuye de forma diferente a los resultados de lectura.

En tercer lugar, la mayoría de los estudios que examinan diferencias en el estatus socioeconómico del vocabulario se basan en medidas que evalúan principalmente la extensión del vocabulario, como las pruebas estandarizadas de reconocimiento de palabras. Por lo tanto, las conclusiones extraídas de estos estudios pueden limitarse a la amplitud del vocabulario. Se sabe mucho menos sobre la influencia del estatus socioeconómico en la profundidad del vocabulario. Es plausible que las diferencias en la exposición al vocabulario influyan no solo en el número de palabras que los niños conocen, sino también en la calidad de sus representaciones léxicas.

En el primer estudio, presentamos datos que muestran que el estatus socioeconómico tiene un impacto significativo tanto en la amplitud como en la riqueza del vocabulario. También descubrimos que el impacto del estatus socioeconómico en la riqueza del vocabulario depende de las tareas que se realizan. Estos resultados destacan la importancia de considerar ambos aspectos del vocabulario y prestar especial atención a las medidas utilizadas al evaluar el vocabulario de los niños. No tener en cuenta el contexto en el que evolucionan los niños puede llevar a subestimar su conocimiento léxico.

Una posible explicación para el impacto más amplio del estatus socioeconómico es que los niños de entornos socioeconómicos más bajos, que a menudo tienen poca exposición al vocabulario, pueden tener menos oportunidades de reforzar las relaciones semánticas dentro de su vocabulario existente, reduciendo no solo la cantidad de palabras que conocen, sino también la profundidad de su vocabulario. Una pregunta relevante que puede surgir es bajo qué condiciones los niños adquieren un conocimiento léxico de alta calidad que contribuya a la

riqueza de su vocabulario, haciéndolo bien conectado y útil para la comprensión y el aprendizaje a lo largo de la vida. Entre la multitud de posibilidades, examinamos el impacto de la modalidad en la integración de representaciones léxicas a lo largo del tiempo como primer paso en el aprendizaje de palabras.

En los Estudios 2 y 3, examinamos cómo las palabras aprendidas oralmente y por escrito se integran en el léxico con el tiempo. Hemos tenido en cuenta la distinción teórica entre configuración léxica y lexicalización. La configuración léxica se refiere al conocimiento general de una palabra, como la forma que puede surgir tras el primer encuentro con la palabra, mientras que la lexicalización se refiere a cuando una palabra nueva pasa a formar parte del léxico y produce efectos léxicos a lo largo del tiempo, incluyendo un reconocimiento más rápido y competencia lexical.

Para examinar estos procesos, los niños aprendieron palabras reales bajo diferentes condiciones de aprendizaje, controlando sistemáticamente el modo de exposición. Evaluamos su conocimiento de palabras recién aprendidas inmediatamente después de aprender para comprender la configuración léxica, y luego una semana después para evaluar la lexicalización. Este enfoque nos permitió seguir el desarrollo de las representaciones ortográficas, fonológicas y semánticas a lo largo del tiempo.

El estudio 2 mostró que la modalidad puede influir en la integración de representaciones léxicas (es decir, ortografía, fonología y semántica). En concreto, descubrimos que aprender a partir de materiales escritos facilitaba la adquisición de la forma de una palabra, mientras que el aprendizaje oral parecía promover una mayor integración semántica tras una semana. El Estudio 3 demostró que la exposición a la ortografía por sí sola producía resultados de aprendizaje comparables a los observados tras la exposición secuencial a la fonología y la ortografía. En otras palabras, la exposición previa a la forma fonológica de una palabra no mejoró significativamente la adquisición de representaciones léxicas.

En conjunto, estos resultados ponen de manifiesto la importancia de tener en cuenta no solo la cantidad de vocabulario, sino también la calidad de las representaciones léxicas, así como la modalidad con la que los niños se encuentran y aprenden las palabras.

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Abbreviations

IPS: Index de Positionnement Social (*Social Positioning Index*)

GPC: Grapheme-Phoneme Correspondences

LQH: Lexical Quality Hypothesis

PGM: Phoneme-Grapheme Mappings

OF: Orthographic Facilitation

OS: Orthographic Skeletons

SES: Socioeconomic Status

Introduction

In one passage of his classic novel, *One Hundred Years of Solitude*, Gabriel García Márquez describes how the people of Macondo are attacked by the insomnia plague after Visitacion and Cataure arrive in the village. This plague makes people forget the names of things which, as Gabriel Garcia Marquez reveals, could lead to the greatest sorrow of all: oblivion. To prevent this catastrophe, Aureliano Buendia devises a way to remember the names of objects: he writes the word for each object on it. Later, he realizes that words alone are not enough, it is necessary to provide further descriptions of the object that is being labeled. For example, "it was necessary to explain that the cow must be milked every morning so that she will produce milk, and that the milk must be boiled in order to be mixed with coffee to make coffee and milk." In the end, he abandons this strategy when he realizes that it will be useless once people forget the value of written letters.

This short passage illustrates some relevant aspects to the work presented in this manuscript. First, it illustrates how important words are in everyday life to name things. Second, it highlights how necessary it is to know their meaning so that we can give a sense to everything that is around us. Third, the existent relationship between the "value of letters", that is, reading, and our ability to appreciate the words that we can use. As we will see, outside the fictional world of Macondo, not knowing enough words can lead to real difficulty during childhood and even beyond. The research presented here aimed to study children's vocabulary and related aspects of word learning. The goal was to improve our understanding of this important ability and contribute to efforts to prevent our children from falling, in García Márquez's words, into oblivion. By the way, it is Melquiades who ultimately provides Aureliano with a remedy that helps people regain their memory and their ability to use words.

The main goal of this text is to present a research agenda consisting of a series of studies on vocabulary and word learning. These studies are intended to contribute to a deeper

understanding of how schoolchildren learn words and the mechanisms behind this process. This project belongs to a wider educational initiative (PIA 3 "*100% IDT: Inclusion, un Défi, un Territoire*") that aims to ground instructional practices on the results of fundamental research in cognitive psychology. For this reason, the studies reported here are based on experimental paradigms that have been taken into the real context of classrooms. While conducting experimental research in schools presents various challenges, both practical and methodological, it allows word learning to be studied in natural contexts, which may more readily inform instructional practices. The general aim of the current research agenda is to investigate children's vocabulary and the mechanisms behind word learning as a pathway to support later reading comprehension. This work therefore seeks to extend the existing literature on word learning and develop instructional devices that facilitate efficient and reliable vocabulary teaching.

This manuscript is divided into three sections. The first section provides the conceptual and theoretical foundations on which this work is based. Chapter 1 presents a general overview about the concept of vocabulary and clarifies the terminology used throughout the manuscript. It also emphasizes the importance of vocabulary in relation to literacy, outlining some of the individual and environmental factors that can influence its acquisition. Please note that, as this thesis focuses on word learning in children at the end of primary school, particular emphasis is placed on the transition from learning to read to reading to learn. In other words, we highlight the different roles that vocabulary can play in the initial stages of decoding compared to when reading comprehension is involved.

In Chapter 2, we begin to introduce the theoretical background on which this work is based. This chapter examines the distinction between having general knowledge of a word, enough to recognize it, and knowing it in greater detail in relation to other words (i.e., Breadth and Depth; R. Anderson & Freebody, 1981; Ouellette, 2006). Furthermore, it describes what

constitutes high-quality lexical knowledge, enabling a word to be recognized based on its own features and in relation to other words for comprehension purposes (i.e., The Lexical Quality Hypothesis; Perfetti & Hart, 2002).

Chapter 3 focuses on the word-learning process and describes a key theoretical distinction, the lexical configuration and lexicalization framework (Leach & Samuel, 2007), contrasting it with the two-stage model of word learning (Davis & Gaskell, 2009). Chapter 4 discusses relevant accounts of word learning such as the Orthographic Facilitation Hypothesis (Ricketts et al., 2009) and the Orthographic Skeleton Hypothesis (Wegener et al., 2018) as they provide complementary explanations of how orthographic and phonological information contribute to word learning. Chapter 5 concludes this section by summarizing the theoretical framework and identifying gaps in the literature that the present work aims to address. This chapter contains thus the research questions and the hypotheses driving this thesis.

The second section of the manuscript is devoted to the experimental contribution. Chapter 6 starts with our first study, in which we examine differences in vocabulary breadth and depth between children from low and average socioeconomic status (SES). Chapter 7 presents two school-based experimental studies on word learning. The first study compares the effectiveness of oral versus written modality in word learning. The second study, examines the differences between two training conditions: written-only and sequential presentation of written and oral modalities. These two studies systematically manipulate the modality of learning to assess the respective contributions of oral and written input to lexical development.

The third section offers a general discussion of this research agenda. Chapter 8 begins with an overview of the research conducted and discusses the findings across all the studies. It considers theoretical points, weighs the limitations of the work, and suggests directions for future research. Chapter 9 focuses on the instructional implications of the findings, particularly those relevant to educational practice. Chapter 10 concludes the manuscript.

SECTION 1

GENERAL BACKGROUND AND THEORETICAL FRAMEWORK

Chapter 1: Vocabulary in context

Words provide the means to indicate objects, express feelings, and persuade others. We use words every day, without being aware of it, to communicate with other humans and even non-humans, like when talking to a pet, a plant or an artificial intelligence. As we will see in this work, words are what compose someone's vocabulary and understanding how we learn them is a complex matter, including different capacities and a variety of individual and environmental processes.

1.1 A notion of vocabulary

Even though, or perhaps because, the study of vocabulary holds a long history from multiple standpoints and different disciplines, defining it remains ambitious. A simple search of the term vocabulary in a scientific database (e.g., PsycINFO) yields almost 50,000 results, each comprising and approaching such concept in different ways. It would be virtually impossible to provide one definition that integrates all that has been said about it. For the sake of understanding, it is better to provide here the conception of vocabulary used in this manuscript. In this work, vocabulary is understood as the aggregation of words in a person's lexicon, along with the fundamental knowledge about them (e.g., orthography, phonology, and semantics). This conception is based on theoretical frameworks that will be further developed in Chapter 2. For now, it can be described as distinguishing between the number of words known (i.e., breadth) and the detailed knowledge of a given word (i.e., depth), as well as the critical interaction between orthography, phonology, and semantics (i.e., lexical quality). As we will see, such interplay is important not only for reading comprehension, but also for learning new words. Note that words have syntactic roles and morphological aspects that, while not deeply considered in this work, can also influence word processing.

In this context, it may also be worthwhile considering the use of word learning and vocabulary acquisition in this manuscript. It should certainly be acknowledged that there are

long-standing debates surrounding the use of these terms (see Lindner & Hohenberger, 2009, for example). According to Lindner and Hohenberg, such terms are used interchangeably in psychology, but it becomes necessary to distinguish between the two when addressing linguistic processes. While these terms will be used somewhat interchangeably throughout this text, the distinction will be considered, broadly adhering to the difference between learning as an intentional process and acquisition as an unintentional one (Van Geert, 1986). For example, vocabulary acquisition occurs when children hear words for the first time and begin to associate them with objects in the world around them, or when they are exposed to words without formal instruction. In contrast, word learning occurs when children are explicitly introduced to words at school or in a research context to be tested on their ability to remember them afterwards.

Words enable us to design, describe, modify, and sometimes, with a little imagination, create what exists in this world. Words can be acquired in a myriad of ways, listening to others, such as parents during early childhood, teachers in school, or friends in conversations; or through reading, whether in books, articles, or even on something as ordinary as a cereal box. Be that as it may, words often have multiple meanings and functions (e.g., adverbs, adjectives, conjunctions, etc.) that must be understood in relation to the surrounding words and broader discourse. This determines whether a word is known and in fact will facilitate learning more.

Building on such conception of vocabulary and the different pathways through which it can be acquired, the research agenda presented here focuses on several aspects of word learning (e.g., lexical development, learning modality) and examines their relationship with other factors (e.g., SES). Understanding such matters may be of particular importance in a world where inequities often stem from gaps that originate from and are reinforced by differences in vocabulary exposure from the earliest stages of life.

1.2 The importance of studying vocabulary

In the last decades, significant efforts have been made to eradicate illiteracy in the world. By 2024, the literacy rate for people 15-to-24 reached 93% worldwide (UNESCO, 2025), yet there are some difficulties concerning basic literacy abilities. The same report indicates that by 2030 there are more than 300 million children at risk of leaving primary school without reaching minimum proficiency in reading. If we consider that children from low-income backgrounds are the ones who find themselves being the most affected by this lag (Buckingham et al., 2013), something has to be done to avoid widening it. This is crucial because such literacy gap can be worsened leading to what is known as the Matthew Effect (Stanovich, 1986). That is, to avoid vocabulary gaps that emerge in early childhood deepening over time if left unaddressed, which reinforces social and economic inequalities.

Vocabulary, notably academic vocabulary, plays an important role in academic life due to its tight relationship with reading comprehension. Different international assessments at the school level show how differences in vocabulary and language comprehension skills are reflected in reading achievement. An international assessment focused on reading achievement at the fourth grade, the PIRLS (Progress in International Reading Literacy Study), revealed a steady long-term decline in reading achievement worldwide during the last two decades (Mullis et al., 2023). The Program for International Student Assessment (PISA), a "global standard aiming to assess students' knowledge and skills essential for full participation in social and economic life", consistently demonstrate that students with stronger vocabulary knowledge achieve higher reading scores, indexed by literal and inferential comprehension (OECD, 2023). In France, despite near-universal school enrollment and a long tradition of literacy instruction, primary students have experienced a decline of more than 10 points during the last 20 years (Bret et al., 2023). Setting aside the utilitarian objectives, these reports demonstrate that the vocabulary children have when taking these tests largely determines the outcome. This notion

is widely supported by research and reinforces the idea that vocabulary should be a primary concern when addressing literacy.

According to research, students with limited word knowledge expend more cognitive energy on decoding and less on integrating meaning, which leads to slower reading growth and weaker motivation to read (Perfetti & Stafura, 2014). Without sufficient vocabulary, even children who can sound out words accurately will struggle to understand what they read (Oakhill et al., 2012). Therefore, vocabulary lies at the heart of reading, literacy, and comprehension. Understanding it well is essential to sustaining gains that attempt to narrow persistent gaps. Providing early vocabulary enrichment, research-based word instruction, and ample reading opportunities will lead to better reading outcomes. In turn, stronger reading skills will increase the opportunities children can obtain later in life.

Therefore, one important reason for studying vocabulary is to enhance reading comprehension, which can help prevent academic setbacks. Since reading becomes a major source of vocabulary learning once children have learned to "sound out" words (R. Anderson & Freebody, 1981; Nagy et al., 1985), it is understandable that much research has focused on how children acquire vocabulary through reading. The argument is that written text presents a much larger and more varied vocabulary than spoken language, providing myriad opportunities to learn new words (Cunningham, 2005). Furthermore, it is impossible to explicitly teach all the academic vocabulary necessary for success at school (Cervetti et al., 2023; Stahl & Fairbanks, 1986). Nevertheless, oral exposure and explicit instruction still play a role in learning words, particularly for children who do not have much exposure to written, academic and varied language at home. This makes investigating the effects of learning words from both written and spoken material a promising research direction. Next, a word on vocabulary acquisition throughout life and a description of some of the factors behind it.

1.3 Vocabulary Acquisition

Even before birth, humans are exposed to language. From the moment the body is able to perceive the outside world, a fetus can hear words, and research suggests that, while newborns may not recognize specific words, they can distinguish the language in which they are spoken (Moon et al., 2013). Further research describes how infants can perceive and discriminate adult speech sounds by one month of age and can distinguish categorically different phonemes in their native language by 4–6 months (Werker & Lalonde, 1988). Through exposure to language and processes of discrimination and imitation of patterns, infants develop the remarkable ability to produce and acquire words through interaction with others. Although the rate of vocabulary acquisition varies from child to child, the first words are generally produced around 12 to 13 months of age (Sheng, 2018). After this, there is a striking lexical explosion in terms of both production and acquisition.

In terms of vocabulary acquisition, rates can go from around two to nine root words (lemmas) per day between 18 months and 6 years old (R. Anderson & Freebody, 1981; Carey, 1978; Nagy et al., 1985). Such exponential growth continues throughout childhood, with 6- to 8-year-olds learning an estimated five new lemmas per day (Templin, 1957). By the end of second grade, children's vocabularies include around 5200 root words (Biemiller & Slonim, 2001). By age 20, estimates by Brysbaert et al. (2016) suggest that someone can have approximately 42000 lemmas, with an increase of 6000 more words by the age of 60.

It is worth noting that the units used to calculate the estimates will influence this variability. So far, only estimates for lemmas have been presented. Lemmas are base forms that group together inflected variants of a word. Let us consider the word *hope*. The lemma will include its inflected forms (*hopes*, *hoped*, *hoping*). However, there are other units of measurement that can be employed. Word families include inflected (*hopes*, *hoped*, *hoping*) and derived forms (*hopeful*, *hopeless*, *hopefully*) whereas word types count each word form as a

separate item (e.g., *hope*, *hopes*, *hoped*, *hoping* are treated as four distinct words). The choice of unit would depend on the purpose of the assessment. If the goal is to estimate meaningful lexical growth over time, Webb and Nation (2017) claim that counting with word families is better because word-family measures may capture both an increase of individual words and the connection with related words. In contrast, when using other units (word type or lemma), an increase in vocabulary size might simply represent an accumulation of knowledge of word parts but not lexical knowledge per se.

1.3.1 Factors involved in vocabulary acquisition

Over the past five or six decades, extensive research has advanced our understanding of how children acquire vocabulary. Below is an overview of some of the factors found to impact this complex process that not only involves cognitive capacities (Baker et al., 1995; Wagner et al., 2007), but also involving environmental factors (Hoff, 2006; Lervåg et al., 2019). Cognitive capacities can include memory and attention (Gathercole et al., 1992; Y.-S. G. Kim, 2017), linguistic abilities (Gupta & Tisdale, 2009; Melby-Lervåg et al., 2012; Metsala, 1999), and vocabulary knowledge itself (Cain et al., 2004; Ricketts et al., 2008; Verhoeven et al., 2011). Regarding environmental factors, we can include school and home interactions (Hoff, 2006; Neuman et al., 2018; Rowe, 2012) and even the way words are encountered in speech (de Carvalho et al., 2016, 2017). Another factor that has been studied is the intrinsic properties of words, such as whether they are verbs or adjectives (Booth & Waxman, 2009; Sandhofer & Smith, 2007) These factors can affect the rate at which words are learned and the depth of lexical representations acquired. Furthermore, the influence of these factors can change as children develop (N. J. Anderson et al., 2021; Simmons & Kameenui, 1990). Given the wide range of factors and variability of situations involved in vocabulary acquisition, please note that the overview presented below is not exhaustive. It only focuses on general aspects that provide insight to understanding such a process during childhood.

1.3.1.1 Individual factors

Acquiring vocabulary, in general terms, implies accurately mapping word forms to their referents and being able to use these mappings effectively (Gupta & Tisdale, 2009). This process depends on the ability to correctly associate spoken or written word forms with their meanings. Consequently, various individual factors have been associated with vocabulary development throughout life, including memory (Baddeley, 2012; Baddeley et al., 1998a; Gathercole et al., 1992), attentional capacities (Baker et al., 1995; Y.-S. G. Kim, 2017; Morra & Camba, 2009), and phonological abilities (Metsala, 1999; K. Nation et al., 2007; Torgesen et al., 1997).

According to Baddeley et al. (1998a), the main purpose of the phonological loop mechanism, a component of Baddeley's (2020) working memory model, is to store novel sound structures while more permanent lexical representations are formed. This seems to be a critical step in learning words (Gathercole et al., 1992). Although this view has been criticized, particularly regarding the use of nonwords to assess phonological loop functioning (Snowling et al., 1991), it remains an accurate account of the initial stages of word learning.

Morra and Camba (2009) further describe how different aspects of memory contribute to vocabulary acquisition. They argue that knowledge of vocabulary, that is, words stored in long-term memory, facilitates the acquisition of new words through phonological processing supported by working memory mechanisms (i.e., the phonological loop). According to their model, once a meaning is associated with a new word, the semantic-phonological activation produced by related words facilitates the acquisition of the new word. This is particularly relevant for understanding how vocabulary gaps emerge between children who start school with a large vocabulary and those who do not. Children who possess a limited vocabulary will have fewer words to activate when encountering novel words, which, according to this model, slows down acquisition.

When learning a new word, children should pay attention not only to its phonological or orthographic form, but also to the context, which may provide information about its meaning. For example, some words are pronounced the same but have different meanings based on the context in which they are used. With this in mind, it is important to note that vocabulary, as a linguistic capacity, is closely related to other linguistic abilities including reading (see last section of this chapter). Such abilities develop in an intertwined, reciprocal manner, meaning that exposure to a wide vocabulary improves language-related capacities, which improve word recognition, which facilitates reading, which increases opportunities to encounter new words, and so on (Cunningham, 2005; Willingham, 2017).

In fact, several studies have found strong associations between early-life vocabulary and phonological abilities (Binder et al., 2017; Bloom & Markson, 1998a; Lonigan, 2007). Similarly, many of these capacities have been described as having a tight, reciprocal relationship with vocabulary acquisition, particularly through reading development (Oakhill et al., 2012; Verhoeven et al., 2011; Wagner et al., 2007). The reason for this is that vocabulary acquisition initially occurs through oral contexts, such as conversation or exposure to oral stimulation. However, as children grow older and learn to read, words are increasingly encountered in written language, which allows for the discovery of novel words not usually found in speech (Nagy & Scott, 2000). Consequently, children with larger vocabularies find it easier to comprehend texts, and skilled comprehenders can infer the meanings of unfamiliar words from context better than poor comprehenders can (Cain et al., 2004).

With this, one of the skills identified as most important for reading development in alphabetical languages, over in English (see below), is phonological awareness (Landi, 2012; Metsala, 1999; Oakhill & Cain, 2012). Phonological awareness is the ability to perceive, discriminate, and manipulate speech sounds in a language. Although the underlying capacities of this skill are debated, as are many concepts in the literature on language development, it is

widely recognized that phonological awareness is the bridge between oral vocabulary and the phonological encoding of graphemes that occurs when reading (Kirby et al., 2025; Melby-Lervåg et al., 2012; Torgesen et al., 1997), which could explain the reciprocal interaction between vocabulary and reading. According to the lexical restructuring hypothesis (Metsala & Walley, 1998), oral vocabulary growth supports the capacity to segment words which allows for the capacity to increasingly discriminate and manipulate phonemic units thus enhancing the discrimination of lexical representations (Metsala, 1999). Our studies did not evaluate such capacity because they did not explicitly require such metalinguistic abilities. Furthermore, more recent accounts have found that such ability is not that important for reading development in all orthographic systems (Zugarramurdi et al., 2022). This raises an important point regarding the research presented here and research traditionally carried out in the language domain, whether with children or adults.

Many of the principles and models that have shaped accounts and descriptions of word learning and its relationship with other linguistic abilities, including reading, in language research are based on alphabetic European languages, particularly English (Share, 2008a). If the transparency of a language's orthography plays a role in the abilities underlying word learning, it is important to bear this in mind, as the principles that apply to the orthographic system of one language (e.g., English) may not apply to another (e.g., French). One example can be the speed of learning to read (cf. Seymour et al., 2003). Of course, when working with typically developing humans, the underlying cognitive mechanisms should be universal, but still the deployment of resources may differ. The studies that will be presented in this manuscript were conducted in French, a language in which the grapheme-to-phoneme correspondences are more consistent than the phoneme-to-grapheme mappings. As we will see later, this may influence the ease with which learners generate and assimilate word representations.

Finally, another linguistic factor related to vocabulary acquisition is prior vocabulary knowledge itself (Biemiller, 2006; Cain et al., 2004). Knowledge of words plays a central role in facilitating the acquisition of new words due to the close interaction between vocabulary and language comprehension (Oakhill et al., 2012). This interaction later becomes a significant factor in reading development (Ouellette & Beers, 2010). Thus, a rich vocabulary supports the comprehension of written and spoken language. Conversely, reading contributes to vocabulary growth and the development of broader oral language skills (Swart et al., 2017; Wagner & Meros, 2010), which launches the reciprocal relationship of vocabulary growth, language comprehension and reading (Oakhill et al., 2012; Perfetti & Stafura, 2014; Wagner & Meros, 2010).

Research has shown that children's ability to recognize individual words becomes more accurate and efficient with increased exposure to them (K. Nation et al., 2007). Therefore, once reading is acquired, children encounter novel words in texts that are not commonly used in oral contexts (Dawson et al., 2021), which increases vocabulary demands. Therefore, the more familiar children are with literacy, the better they will be able to overcome such demands. As we will see next, the environment in which children grow up plays a significant role in vocabulary acquisition and literacy development.

1.3.1.2 Environmental Factors

In their classical study, Hart and Risley (1995) revealed that exposure to words prior to literacy acquisition significantly influences vocabulary knowledge. Most importantly, they demonstrated that this exposure significantly varies across socioeconomic backgrounds. Such differences led to dramatic observed differences in vocabulary by the beginning of primary school between children from low and high SES backgrounds (Hart & Risley, 2003). This means that beyond individual characteristics, environmental factors also contribute to variability in the complex process of acquiring words. These factors include caregiver-child

interactions, the home literacy environment, instructional practices, and peer exchanges (Buckingham et al., 2013; Hoff, 2006; Neuman et al., 2018). This is not surprising, since these contexts together shape children's opportunities for incidental word learning and explicit discussions about word meanings.

Research has identified parental input as a primary source of variability in children's vocabulary knowledge. Huttenlocher et al. (2010) demonstrated that lexical diversity (using different words to refer to the same object) and syntactic complexity in parental speech are linked to children's vocabulary growth and subsequent language production. In her study, Rowe (2012) found that the quantity of linguistic input children receive predicts their vocabulary development. First, she reported significant variability in the amount of speech directed at children. During a 90-minute interaction with 18-month-olds, some parents spoke as few as 360 words, while others spoke more than 9,200. Most importantly, this variation was significant, with children exposed to more words producing more words.

Rowe and Snow (2020) further pointed out that the relative contributions of input quantity (i.e., number of words) and quality (i.e., richness and variety of language) shift over the course of development. They found that at 18 months, children's vocabulary size was primarily predicted by the quantity of input. However, by 30 months, lexical diversity became a significant predictor, even when controlling for quantity. Quality of language includes lexical diversity, syntactic complexity, decontextualized language use, and socially interactive features, such as joint attention and contingent responses. By 42 months, the only significant predictor was parents' use of decontextualized narrative language. This type of language refers to speech that is unrelated to the present moment (e.g., referring to past or future events) or that explains how things work in the real world. Anderson et al. (2021) extended these findings by demonstrating that, as children become more linguistically and cognitively mature, they benefit

more from complex, conceptually rich input. Nevertheless, progress will be compromised if the input falls short, even with a well-developed system.

Support for the impact of input on the nature of the earliest words produced by children comes from an early study by Nelson (1973). She observed that children's first words typically refer to people, animals, food, and toys. Notably, she observed differences between children with a referential style, emphasizing object labels, and those with an expressive style, emphasizing social interaction. She argued that these differences reflect children's views of language use, which in turn, are influenced by parental language use. Supporting this view, Pine (1994) found that parents who frequently used object labels were more likely to have children with a referential style.

Thus, children's vocabulary development also depends on their linguistic environment. Early in development, the quantity of input plays a dominant role by providing opportunities for exposure to words. As children's language skills mature, the quality of input becomes more influential, supporting the development of a richer, more interconnected vocabulary. As we will see next, this is not only a matter of the household, school context also plays a role. Socioeconomic backgrounds significantly impact linguistic opportunities, creating disparities in interaction environments, communication quality, and educational resources. These disparities create inequalities in opportunities that eventually amplify gaps in vocabulary development.

1.3.1.2.1 Socioeconomic Status (SES)

Given the importance of children's immediate environment and surrounding language use, it is essential to consider socioeconomic background, as family SES is a central factor shaping these interactions (Buckingham et al., 2013; Hoff, 2006; Neuman et al., 2018). Indeed, SES is typically operationalized through indicators such as family income, parental education, and occupation, and has been consistently associated with multiple factors that directly and

indirectly affect children's cognitive and language development (for a review see Bradley & Corwyn, 2002).

Students from lower-SES backgrounds frequently exhibit poorer academic outcomes than their higher-SES peers (Schoon et al., 2012). This pattern has been associated with limited language exposure and lower educational attainment in low-income families (Hoff, 2013; Nag, 2023). For example, Hoff (2003), put into evidence that children in higher-income families, measured through parent's educational level and job positions, are spoken to more frequently, and the speech they hear is richer in terms of syntactic complexity and referential variability. Notably, SES is associated with not only language quantity but also lexical diversity, syntactic complexity, and decontextualized language use (Hart & Risley, 2003; Hoff, 2013; Huttenlocher et al., 2007). As we have seen, these factors have been shown to support vocabulary development.

In a study analyzing the language directed at children of 4 and 5 years, Neuman et al. (2018) compared home and kindergarten settings in neighborhoods with high concentrations of poverty and in borderline neighborhoods. They found that children growing up in high-poverty areas were exposed to language that was less lexically diverse and syntactically complex from both parents and teachers. Moreover, the quality of language input from both sources predicted children's language and early literacy skills, in line with Rowe's (2012) findings. Similarly, Buckingham et al. (2013) identified instructional quality and teaching practices, both of which are strongly influenced by SES, as factors associated with vocabulary growth in English-speaking countries. Thus, the disadvantage of reduced support for language learning among children from low-SES backgrounds is not limited to the household; it extends to educational contexts as well.

In France, SES is operationalized at the school level through a national composite indicator, the IPS (Social Position Index; Dauphant et al., 2023), that is based on the

socioeconomic and cultural background of students' families (e.g., parents' occupation and education, number of books at home). Schools with low scores on this index (National Mean = 104; range 45-185), are typically located in socioeconomically disadvantaged areas. Such areas are designated as REP (Priority Education Network), with those with the lowest scores being REP+. Various reading and educational reports indicate significant differences in academic proficiency between students attending non-priority schools and those attending REP+ schools. Disparities in vocabulary-related skills, such as identifying words from the same family and finding synonyms, are particularly notable (Andreu et al., 2024; Bret et al., 2023; Fernandez & Giraudeau-Barthet, 2023). While there is no evidence linking these disparities to instructional practices in France, given that all the schools follow the same curriculum, regardless the socioeconomic background of the school, we cannot rule out that teachers' beliefs about children's abilities based on their SES could play an unconscious role (Faivre, 2021).

Regardless the country, these SES-related differences in linguistic experience lead to differences in children's language development (Fernald et al., 2013). As discussed above, linguistic input is a primary source of vocabulary acquisition. Reduced exposure limits children's opportunities to acquire the vocabulary necessary for academic achievements and, as Huttenlocher et al. (2010) suggest, it may also constrain their ability to verbally express themselves in different contexts. This aligns with Bourdieu's (1986) concept of embodied cultural capital, which refers to the knowledge and dispositions, especially language patterns, that individuals internalize through daily interactions, particularly with their families.

Middle- and upper-SES families often encourage speech and interaction patterns that closely align with school expectations. Children raised in these contexts are frequently exposed to a more formal or academic style of speech, facilitating their adaptation to school settings. In contrast, children whose home language practices differ from those valued in educational institutions, often from lower-SES backgrounds, may experience difficulties in contexts that

implicitly reward academic fluency and specific communicative styles. Relating to Gabriel García Márquez's oblivion, there is Bourdieu's symbolic violence, whereby institutions inadvertently disadvantage certain cultural backgrounds by valuing vocabulary and forms of language and interaction that not all children have had equal opportunities to acquire.

It is important to acknowledge, however, that although there are strong correlations between SES and disparities in children's language and literacy environments, these relationships are not deterministic. Parental beliefs and attitudes toward reading play a crucial mediating role in shaping children's early literacy experiences, independent of SES (Boonk et al., 2018; Cottone, 2012; DeBaryshe, 1995; S. Kim, 2022; Sénéchal & LeFevre, 2002). For example, in a review on parental involvement and educational outcomes, Kim (2022) identified high parental expectations for children's academic achievement as the most consistent predictor of educational attainment. DeBaryshe (1995) had already proposed that children's early literacy experiences at home are influenced by parents' beliefs about the purpose and developmental progression of reading. Building on this, Cottone (2012) found that maternal beliefs mediate the relationship between maternal education and children's early literacy skills, thus nuancing Hoff's (2003) previous findings. Therefore, parents in low-income households can provide stimulating literacy environments by setting high academic expectations, valuing schooling, and actively encouraging and supporting learning.

The message here is that SES influences vocabulary development beyond differences in verbal interactions between caregivers and children. It also often accounts for differences in opportunities to encounter and discuss novel concepts in various contexts. Although children from low-SES backgrounds can experience these opportunities, they are less likely to engage in experiences such as museum visits, extracurricular activities, and being read to (Hoff, 2003, 2006, 2013; Ma et al., 2024). They also generally have less access to books (Brossette et al., 2025), which can hinder their ability to develop a more extensive and diverse vocabulary.

Chapter 2 discusses how these two domains of vocabulary, particularly depth, are central to lexical knowledge and play an important role in word learning and reading. First, however, let us briefly review the relationship between vocabulary and reading, given their tight reciprocal relationship.

1.4 Vocabulary and reading

Across these pages, word learning has been, and will likely continue to be, discussed in relation to reading. This is because once children learn to read, written language becomes a primary source of vocabulary growth (Cunningham, 2005). The population in our studies include children transitioning from learning to read to reading to learn, that is, they are shifting from an emphasis on decoding and recognizing written words to understanding and learning from written material (Chall, 1983; Ehri, 2005a). Thus, we were able to assess word learning through written and spoken material. Moreover, the ultimate goal of learning words is to comprehend texts that contain them and retrieve and apply them effectively when needed (Beck et al., 2013).

For over a century already, there have been suggestions that vocabulary is an important predictor of later reading success (Dickinson, 1920). Further support comes from evidence showing that vocabulary is tightly related to reading comprehension (R. Anderson et al., 1988; Oakhill et al., 2015; Stahl, 2003). This relationship is certainly reciprocal, meaning that a broad vocabulary facilitates reading and further reading increases vocabulary (Cunningham, 2005; K. Nation, 2017; Oakhill et al., 2012; Wagner & Meros, 2010; Willingham, 2017); for this reason, it lies at the core of the practical objectives of this thesis. If children who struggle with academic vocabulary can catch up and develop a strong vocabulary, they may be able to meet the demands of school and overcome possible literacy-related disadvantages in the future.

Indeed, the reciprocal relationship between vocabulary and reading complicates attempts to isolate vocabulary developments as it progresses. For example, Simmons and Kameenui

(1990) explored the relationship between vocabulary knowledge and reading comprehension across age. They found that, by age 10, students with learning disabilities had weaker vocabulary skills than their peers, even when accounting for reading ability. However, by age 12, these vocabulary differences were no longer evident when considering reading comprehension. The authors concluded that reading and vocabulary become mutually dependent over time, making it more difficult to distinguish vocabulary as an independent skill later in development than during early childhood.

The relationship between vocabulary knowledge and reading comprehension has been explained in three ways (R. Anderson & Freebody, 1981; Wagner & Meros, 2010). First is the instrumentalist hypothesis, which suggests that vocabulary knowledge directly supports reading comprehension. In this view, knowing the meanings of more words makes reading comprehension easier because identifying individual lexical items is necessary for understanding a text. Second is the knowledge hypothesis, which suggests that reading comprehension reflects broader conceptual knowledge. From this perspective, comprehension stems not from vocabulary itself, but from the underlying network of concepts that someone can have and the relationships within that network. The third explanation, the aptitude hypothesis, suggests that the correlation results from underlying cognitive aptitudes or learning capacities. According to this view, the same abilities that enable individuals to efficiently acquire vocabulary may also facilitate reading.

These three hypotheses have undoubtedly improved our understanding of the various factors related to vocabulary and reading, as well as their relationship. Furthermore, subsequent discussions have suggested that these hypotheses are not mutually exclusive. According to Stahl (2003; 1986), the relevance of each hypothesis may depend on the context in which words are encountered, the nature of the comprehension task, and individuals' knowledge of a word. Empirical research examining whether improving vocabulary leads to better reading

comprehension has produced inconsistent results (Wright & Cervetti, 2017). While some studies suggest that extensive vocabulary instruction can modestly improve comprehension (Stahl & Fairbanks, 1986), many others show that approaches focusing primarily on definition memorization have little impact on this ability (Beck et al., 2013; Cervetti et al., 2023).

Despite the complexity of the relationship, research consistently shows that vocabulary knowledge plays an essential role in reading development at all grade levels (Muter et al., 2004; Oakhill et al., 2012; Stahl, 2003; Verhoeven et al., 2011; Wagner et al., 2007). Meaning that having good knowledge of vocabulary contributes to reading processes. Furthermore, there is also evidence that individuals who can comprehend written texts are more likely to engage in reading activities, allowing them to be exposed to new words and thus contributing to vocabulary growth (Cain et al., 2003; Nagy et al., 1985). In short, increasing vocabulary leads to repeated exposure to written language, making reading an important mechanism for expanding vocabulary knowledge (Willingham, 2017).

In this line, research shows that poor readers struggle to infer the meaning of new words they encounter in text (Cain et al., 2004; K. Nation et al., 2007). Cain et al. (2004) presented children with short stories containing a novel word. The meaning of this word could be inferred from contextual cues placed either immediately after the word or several sentences later. Poor comprehenders were less able to explain the meanings of novel words than good comprehenders, especially when the contextual cues were more distant. Nation et al. (2007) supported this finding and concluded that poor comprehenders' difficulties with lexical learning may be localized to the semantic rather than the phonological component of vocabulary learning.

Further studies have shown that vocabulary knowledge improves reading comprehension and the ability to read words with irregular spellings in English, such as *yacht* (Ricketts et al., 2008, 2016). Ricketts et al. (2008) found that both receptive and expressive vocabulary

explained unique variance in the ability to read irregular words among fourth-grade English-speaking children, even after controlling for age, nonverbal intelligence, and decoding skills. Similarly, Ricketts et al. (2016) demonstrated that six-year-olds' semantic knowledge facilitates reading both regular and irregular words, with contextual support being particularly important for irregular words.

Thus, children with poor comprehension have more difficulty acquiring vocabulary from text, while children with limited vocabularies also struggle to understand what they read (Cain et al., 2003, 2004; Cain & Oakhill, 2014; Stahl, 2003). This self-reinforcing dynamic is often described through the “Matthew effect” (Stanovich, 1986), according to which children with stronger vocabulary skills benefit more from subsequent opportunities to acquire new words while those with vocabulary gaps remain often behind. For this reason, understanding vocabulary and investigating the conditions that could lead to a good lexical development can be a first step to closing these gaps.

The next two chapters will present the theoretical framework underlying the current research agenda. We will delve deeper into what it means to know a word and how a word goes from being unknown to being known. Then, we will consider the possibility that modality plays a role in this process. Next, we will present the experimental contribution of this thesis.

Chapter 2: What does it mean to know a word?

The previous chapter outlined a definition of vocabulary that includes the quantity and detail of word knowledge. The present chapter establishes the theoretical basis for this distinction, which is particularly important for the first study of the current research agenda. Furthermore, we will delve deeper into what it takes for a word to be useful for comprehension. In this way, we first describe what could it mean to know a word and for this, we identify two key domains of vocabulary: breadth and depth (R. Anderson & Freebody, 1981; Ouellette, 2006). Next, we present a framework that conceptualizes lexical knowledge as the incorporation and interconnection of various representations (i.e., the Lexical Quality Hypothesis; Perfetti & Hart, 2002).

2.1 Vocabulary Breadth and Depth

Early vocabulary researchers recognized that word knowledge exists along a continuum. Cronbach (1942), for example, identified five components relevant to evaluating word knowledge: generalization (the ability to define a word), application (the ability to recognize appropriate usage), breadth (the number of words known), precision (the ability to use a word correctly), and availability (the ability to use a word when speaking or writing). Similarly, Dale (1965) proposed a four-level scale spanning from complete familiarity (knows the word well) to complete unfamiliarity (does not know the word). Later on, Nagy and Scott (2000) defined word knowledge as having five properties: incrementality, polysemy, multidimensionality, interrelatedness, and heterogeneity. Other researchers have described word knowledge as dimensional, hierarchical, contextualized or decontextualized, and partial or comprehensive (Webb, 2012). In sum, all of these perspectives emphasize that knowing a word involves multiple components and degrees of knowledge rather than a simple known or unknown distinction.

This supports what was discussed before, that there is no universal definition of vocabulary. However, there is broad agreement that word knowledge cannot be reduced to a yes-or-no classification. Recognizing or producing a word does not mean that one knows it, at least not completely. For instance, a person may recognize a word orthographically or phonologically without fully grasping its meaning. There is even evidence that individuals can distinguish between appropriate and inappropriate uses of words at rates above chance, including words they previously judged as unfamiliar (Shore & Durso, 1990).

To clarify this complexity, some researchers have suggested that vocabulary knowledge varies both in extent and in type, distinguishing between *vocabulary breadth*, meaning the number of words known by someone, and *vocabulary depth*, meaning a detailed knowledge of word meaning (R. Anderson & Freebody, 1981; Meara & Wolter, 2009; P. Nation, 2019; Ouellette, 2006; Richards, 1976). This distinction implies that it is possible to have partial, incomplete, or context-specific knowledge of a word and ignore further figurative or contextual meanings of the same word. For example, take the word *carrefour*. In France, a child normally knows the word because it refers to a well-known supermarket chain. The child may recognize the word's form or pronunciation and associate it with a familiar place, but the same child may not know that the same word also refers to a crossroad and may not understand its figurative uses (e.g., être à un carrefour de sa vie, "to be at a turning point in one's life"). In this case, the child knows the word, counting it in his vocabulary breadth but its knowledge is restricted to a specific context and does not include its broader semantic network, lacking depth. In one of our studies, we examined whether these domains of vocabulary can also be independently impacted by school's socio-economic level.

The distinction between breadth and depth of vocabulary also sheds light on the relationship between vocabulary and reading development. As noted before, a child's initial ability to read is significantly impacted by the quantity and quality of language they are exposed

to (Rowe, 2012). Beck and colleagues (2013), propose that knowledge of words and the ability to make flexible associations between them improves the ability to quickly access a word's meaning. According to this framework, then, word recognition, which is necessary for comprehension, is facilitated not only by the number of lexical representations but also by the depth of knowledge of those representations.

In this way, the ability to link a word to its meaning indicates vocabulary breadth (Schmitt, 2014). Standardized tests that require identifying or producing a lexical form given a prompt (e.g., matching an image with a word) typically offer this information. These measures are straightforward because they provide a number that can be used to draw inferences about how many words a person knows. Classic examples are The Peabody Picture Vocabulary Test (Dunn & Dunn, 2007), and the Woodcock-Johnson III-Picture Vocabulary (Woodcock et al., 2007). In these types of tests, participants are required to match a picture with a word presented orally. Other examples include yes/no questions, that ask participants whether they recognize a word or not (Meara & Milton, 2003), and matching word forms with meanings such as the vocabulary size test by Nation and Beglar (2007).

Vocabulary breadth assessments are the most common measure used to estimate vocabulary knowledge. However, as mentioned in Chapter 1, the method employed will influence the number of words deemed to be known by an individual. In other words, the number of words a person is considered to know depends partly on the content and structure of the test itself. If the vocabulary assessment does not correspond to the experiences or linguistic environments of the children being tested, their performance may underestimate their actual lexical knowledge. This is significant because not all children contribute equally to average test scores simply because they do not have the same opportunities to learn words at the same rate. Biemiller and Slonim (2001), for example, report that children in the lowest quartile for

vocabulary size acquired only one new word per day from age one to the second grade, whereas those in the highest quartile acquired three.

Another point to consider is that vocabulary size is typically estimated using receptive rather than productive measures. Beyond the practical advantages of easier assessment and standardization, this is also relevant because, using a receptive test with "standardized words" to compare, for example, children raised in rural environments who have extensive knowledge of animal or plants names against children raised in environments where they encounter more "standard" lexical domains is clearly biased. Vocabulary tests that rely on a biased set of items may provide an incomplete representation of children's lexical knowledge and potentially underestimate the vocabulary strengths of certain groups.

Moving forward, achieving an operationalization of depth has proven more challenging. Paul Nation (2001) proposed a framework that describes the various components to consider when evaluating vocabulary depth, including word-specific features related to usage such as grammar, syntax, collocations, and register. However, Meara and Wolter (2009) point out that assessing different aspects of word knowledge separately does not necessarily provide a complete understanding of an individual's overall vocabulary knowledge. To understand the relationship between vocabulary and learning words from context, it is more informative to evaluate the interconnected structure and extended knowledge of vocabulary. To this end, some formal tests have been developed to evaluate vocabulary depth, reflecting the various ways it is conceptualized, including precision of meaning, comprehensive word knowledge, and network knowledge (Read, 2004). Examples of these tests include the Vocabulary Knowledge Scale (VKS), developed by Wesche and Paribakht (1996) and the Word Associates Test (WAT), developed by Read (1998). These tests assess detailed knowledge of individual words and how they relate to other words. For instance, participants might be asked to provide the attributes of

an object (e.g., a Kimono is a piece of clothing and is used with a belt, called obi) or find synonyms for a given word.

In line with the above, to evaluate the actual impact of vocabulary knowledge on reading, it is important to consider how well meanings are understood and how extensive vocabulary knowledge is. In other words, knowing words and being able to retrieve information about them are the most useful indicators of vocabulary knowledge. In turn, these indicators can contribute significantly to understanding the impact of reading on learning new words (Perfetti & Stafura, 2014). Substantial evidence shows indeed that breadth and depth provide unique predictive value for reading abilities and vocabulary acquisition (Binder et al., 2017; Cain & Oakhill, 2014; Oakhill et al., 2012; Ouellette, 2006; Tannenbaum et al., 2006). Yet, some authors have questioned the necessity of distinguishing between these two domains due to their strong correlation (Lawrence, 2018; Vermeer, 2001). Most of these reservations, however, are related to how vocabulary is measured and how both constructs are operationalized. In their studies, Vermeer and Lawrence used measures of vocabulary that examined the relationship between words. Since they found strong correlations between these measures, they claimed it was futile to distinguish between these two facets of vocabulary.

Of course, these aspects of vocabulary are inherently interconnected. For example, the most common measures used in research examining the relationship between vocabulary and reading are picture naming and word definition. While the former is commonly used to measure vocabulary breadth, the latter has been used to measure both vocabulary breadth (Tannenbaum et al., 2006) and depth (Cain & Oakhill, 2014; Ouellette, 2006). It can certainly be argued that, while these tests provide an estimate of vocabulary breadth, they also require a certain amount of semantic knowledge to name an image or identify a word's meaning. Other types of tasks include those that assess word relations (e.g., synonyms), reflecting the structure and interconnectedness of vocabulary. Again, it can be argued that these tasks tap into depth, but

they might also reflect breadth because knowing more words allows you to make more connections between them. According to Ouellette and Shaw (2014), these two constructs indeed complement each other by tapping into different levels of knowledge of a word, consequently contributing differently to reading comprehension processes. Therefore, to understand differences in vocabulary completely, it is beneficial to consider that size is not the same as depth. For example, someone may know many animal names, such as *elephant* and *hyrax*, yet be unable to identify that they are related by a common ancestor. This is sometimes not captured when evaluating vocabulary. Furthermore, as we will see in our first study, they can also be uniquely impacted by different factors (e.g., SES).

The most cited evidence of the unique contributions of vocabulary breadth and depth to reading comes from Ouellette's (2006) well-known study, in which he showed that the two predicted fourth-grade students' reading outcomes differently. Breadth explained the variance in decoding skills, while both breadth and depth contributed to word recognition. However, only depth predicted reading comprehension. Ouellette first suggested that greater exposure to words enhances sensitivity to phonemic patterns, which improves decoding. He also suggested that precise, well-integrated semantic representations support coherent text understanding.

Further evidence comes from studies investigating the distinction between the two vocabulary domains and their relationship with different reading capacities (Cain & Oakhill, 2014; Tannenbaum et al., 2006). Tannenbaum et al., (2006) used tasks measuring breadth, depth, and fluency of word knowledge to demonstrate that a two-factor model of breadth and depth/fluency most accurately explains vocabulary. They also found that breadth was more strongly related to reading comprehension. However, the two dimensions of vocabulary exhibited significant overlap in variance contributing to reading comprehension prediction. Cain and Oakhill (2014) examined the influence of vocabulary on reading comprehension and inference-making and found that depth was a significant and unique predictor of global

coherence inferences. They concluded that making this type of inference taps into the semantic relations between different words; therefore, it relies more on the richness of an individual's semantic network, which is captured by measures of vocabulary depth.

In sum, vocabulary cannot be fully understood without the distinction of vocabulary breadth and depth. Furthermore, evidence supports the idea that a greater number of lexical entries and deeper memory representations explain unique variability in efficient reading processes. Nevertheless, it is depth that seems to facilitate the creation of semantic networks that enable comprehension and, consequently, word learning. As we will see next, this idea is supported by an account that attributes a good deal of responsibility for reading comprehension to lexical knowledge.

2.2 The Lexical Quality Hypothesis

According to the Lexical Quality Hypothesis, knowing a word means having strong orthographic and phonological representations of it, as well as a flexible semantic representation, and an interactive connection between these representations (LQH; Perfetti & Hart, 2002; Perfetti & Stafura, 2014). Thus, for words to be fully integrated and useful for comprehension – of high quality – they must include these three interconnected representations. One is its meaning, or *semantic representation*. For example, knowing that *allegory* is a literary device used to convey a moral or political message. Another is its *phonological representation*, or how the word is pronounced (al-uh-gawr-ee). The third is its orthographic representation, or how the word is spelled.

The LQH provides a theoretical framework that explains how vocabulary knowledge supports reading comprehension and why differences in lexical knowledge result in disparities in reading performance. According to this theory, knowledge of words is central to understanding both word learning and text comprehension (Perfetti, 2007; Perfetti & Stafura, 2014). In this sense, it represents a bridge to understanding the widely described relationship

between reading and vocabulary. Along with other theories (see the Lexical Legacy Hypothesis; K. Nation, 2017), the idea is that words are acquired and added to the vocabulary through spoken and written language. As words are encountered repeatedly across contexts, their meanings are refined, and their positions within the lexical system are strengthened and stabilized.

According to Perfetti (2007), the strength and stability of a word's representations define its lexical quality, which depends on two central properties, specificity and redundancy. Specificity refers to the precision of the mapping between form and meaning. Redundancy refers to the convergence of phonological and orthographic information onto the same lexical entry. Ideally, a single orthographic representation would be associated with a clearly specified lexical entry. However, when this mapping is ambiguous or underspecified, lexical quality is reduced, which can lower representational specificity unless contextual constraints sharpen the distinction. Furthermore, strong representations consistently integrate sound and spelling information. When redundancy is low, representations are more fragile. For example, "tear" corresponds to two pronunciations and two meanings ("to rip" and "a drop from the eye when crying"), both of which are linked to the same spelling. Since the phonological information only partially overlaps, each representation is less redundant and therefore less stable.

In addition to form precision, lexical quality critically depends on the richness and organization of semantic information (i.e., vocabulary depth). High-quality semantic representations are precise and flexible, and they are embedded within dense associative networks (Perfetti & Stafura, 2014). During the reading process, these representations are expected to rapidly activate the meaning of the target word and related concepts. Therefore, lexical quality is a crucial aspect of vocabulary depth.

As previously mentioned, vocabulary depth supports higher-level processes, such as generating inferences and integrating information from reading (Cain & Oakhill, 2014).

Assuming word reading is a preliminary step to making inferences and comprehending text, having strong semantic representations fosters acquiring high-quality lexical representations through reading. Indeed, research shows that vocabulary depth impacts word-reading proficiency in late childhood and early adolescence. For example, Eason et al., (2013) found that definition tasks were better predictors of reading rate than vocabulary breadth measures. Furthermore, Ouellette and Beers (2010) and Ricketts et al. (2007) found that definitional knowledge explained unique variance in reading irregular words. In other words, words that cannot initially be recognized by their forms because they are unknown, for example, likely rely on a strong lexico-semantic network for integration.

Thus, high-quality representations can be retrieved rapidly and automatically, providing immediate access to lexical information when encountering a word. In contrast, low-quality representations are underspecified, unstable, and weakly interconnected. If high-quality lexical representations develop from well-specified phonological, orthographic, and semantic features that are tightly interconnected, then how are these representations formed in the first place? One possible approach to answering this question is to focus on the dynamic processes through which they are formed. Examining the word-learning process itself may help us identify the mechanisms that influence the quality of these representations. One possibility is to examine factors influencing lexical development (e.g., learning modality). The following chapters present a framework for understanding the lexical development process and research showing how differences in learning experiences, including learning modality, shape the strength, precision, and interconnectedness of lexical representations.

Chapter 3: The Word Learning Process or Lexical Development

In Chapter 1, it was outlined how exposure to words even before birth enables continuous vocabulary growth extending well into adulthood. New words can be encountered through oral modalities, such as having conversations and listening to others speak, or through written modalities in academic contexts and independent reading after acquiring literacy. Some of these words may be neologisms, such as *rage bait* ("Oxford Word of the Year 2025," n.d.), which refers to online content deliberately designed to provoke anger or outrage. Others may be technical terms acquired as one develops expertise in a specific field, like psycholinguistics (e.g. *lexicalization*). Regardless of their source, new words must undergo a process by which they go from being unfamiliar stimuli to useful lexical entries.

The previous chapter discussed what it means to know a word and described vocabulary in terms of breadth, depth, and lexical quality. However, an important question remains: What happens between the time a word is first heard or seen, and the time it can be recognized, understood, and flexibly retrieved? Which processes allow a word to become part of one's vocabulary and connect meaningfully with other lexical entries? In the current chapter, a framework describing such a process will be presented.

Several theoretical propositions have attempted to explain how words are initially acquired. One influential example is the fast-mapping phenomenon, which refers to the ability to form an initial association between a new word and its referent after only a few exposures. Fast mapping has been documented in children (Carey & Bartlett, 1978) and adults (Carey, 2010; Coutanche, 2026), contrasting with extended mapping, which involves gradually refining and enhancing a word's meaning over time. Other accounts, particularly those focusing on early childhood, have emphasized the inferential strategies and constraints that guide word learning across contexts (Bloom & Markson, 1998b; Carey, 1999; Landau et al., 1988). Since there are countless possibilities for labeling objects or events, the idea is that young learners rely on

cognitive biases or principles that narrow down possible meanings, supporting initial mappings between words and their referents.

According to these studies, forming an association between a new word and its referent is equivalent to learning the word. While these approaches offer valuable insights into the mechanisms underlying early word learning, establishing an initial connection between a word and its referent does not necessarily mean the word has been completely learned (see McMurray et al., 2012 for a discussion). Within the approach adopted in this thesis, learning is not equated with initial mapping alone. Rather, we looked to examine when it becomes efficiently retrievable and has well-specified phonological, orthographic, and semantic features as well as connectivity with other lexical entries in the mental lexicon.

Accordingly, the word-learning studies in the present work conceive word learning as a trajectory unfolding from the initial encounter to the integration of the word into lexico-semantic networks. This perspective enables us to examine how words are initially encoded and how they interact with existing lexical representations. Building on this, a theoretical distinction of the information that can be acquired during the first stage of acquiring a lexical representation and the later stage of lexical integration. This is based on two theoretical propositions that describe how lexical representations are formed (Leach & Samuel, 2007) and stored in memory (Davis & Gaskell, 2009).

3.1 Lexical Development: From configuration to lexicalization

To describe the lexical development process, that is the process by which a word goes from unknown to known, Leach and Samuel (2007) distinguished between the knowledge of a word's factual properties (e.g., orthography, phonology, and semantics) and its dynamic behavior reflecting integration within the lexicon. They argue that learning a word is an incremental process because initial exposure provides only some of the information necessary for a complete lexical entry. Thus, evaluating these processes through different tasks at a given

time can provide information about lexical knowledge and how well a word is integrated into the lexicon.

Based on this, they proposed a key theoretical distinction between what they called *lexical configuration* and *lexical engagement* (Leach & Samuel, 2007). Lexical configuration is the general knowledge of a word's like for example the form that might emerge after the initial encounter with the word or its meaning based on the semantic information available. Lexical engagement, on the other hand, occurs when the newly learned word begins to interact with existing words due to its integration into the mental lexicon. The idea that lexical representations interact dynamically is supported by computational models of word recognition during reading and listening.

These models, known as interactive activation or connectionist models, describe lexical processing as the result of distributed activation patterns, competition among similar representations, and bidirectional influences between different levels of representation (Grainger & Ziegler, 2007, 2011; Harm & Seidenberg, 2004; McClelland & Elman, 1986; Seidenberg & McClelland, 1989). Such description is based on simulations of word processing using connectionist learning networks. This means that orthographic, phonological, and semantic information are represented as patterns of activation across interconnected modules and that learning occurs through gradual adjustments to connection weights in response to exposure. These networks typically operate according to the principles of interactive activation proposed by McClelland and Rumelhart (1981), implying that processing is both cumulative and synergistic between processing units (e.g., lexical entries, phonemes, and letters), with the nature of this interaction being either positive, negative, or neutral, depending on compatibility between them. From this perspective, lexical configuration corresponds to the strength and precision of the learned mappings between form and meaning while the dynamic interaction described by Leach and Samuel occurs in response to the activation of a lexical item at all levels

and can be expressed as facilitation or inhibition. For example, the word *book* can activate de word *boot*, both when seen or heard, because of the shared orthographic and phonological features. Furthermore, it can also activate the word *library* given their semantic relationship.

The distinction between lexical configuration and lexical engagement aligns with the Complementary Learning Systems (CLS) account of word integration into memory (Davis & Gaskell, 2009). According to this framework, initial encounters with novel words result in episodic representations encoded by the hippocampus. Such representations may correspond to the initial information necessary for the lexical configuration. Over time and through offline consolidation processes, such as sleep, these representations gradually transfer to the long-term neocortical memory network, enabling integration into the lexicon thus supporting lexical engagement.

Empirical evidence supports this two-stage model for learning spoken and written words in adults (Clay et al., 2007; Davis et al., 2009; Gaskell & Dumay, 2003) and children (Henderson, Weighall, & Gaskell, 2013; James et al., 2019; Tamura et al., 2017; Weighall et al., 2016), showing notably that it takes some delay for lexicalization to appear, including at least a night of sleep (Dumay & Gaskell, 2007; Henderson et al., 2012; Wang et al., 2017; but see Kapnoula et al., 2015). More recently, Gaskell (2024) proposed an update to the model, claiming that the two systems work together during learning and recognition of words, depending on the material being learned and the context. According to him, the transition from initial learning to full lexical integration is dynamic and influenced by context, rather than strictly sequential.

In any case, a consistent distinction emerges across these theoretical perspectives between two functional states of a newly learned word. Initially, a new lexical item can be recognized based on the traces created during its first encounter about its form and possible meaning. This stage will continue to be referred to as lexical configuration (Leach & Samuel, 2007).

Subsequently, the word becomes integrated into the lexicon, exhibiting lexical effects over time, including faster recognition and lexical competition (Davis & Gaskell, 2009; Leach & Samuel, 2007). This stage will henceforth be referred to as lexicalization.

This slight change in terminology is intended to maintain the distinction established by Leach and Samuel (2007) while emphasizing the process by which a word becomes a permanent part of the lexicon. Lexical configuration effectively captures the acquisition of a word's form-meaning mapping. In contrast, engagement may not entirely capture the structural changes that occur when a word becomes part of the lexicon. While it describes what a word does during processing and emphasizes interaction, it remains relatively ambiguous regarding the process of lexical integration. First used by Dumay and Gaskell (2003), the term lexicalization is more suggestive of the integration of a lexical entry into lexicon and is equally used by researchers interested in these processes (see Bakker et al., 2014; Kapnoula & McMurray, 2016; Takashima et al., 2017). Importantly, this distinction is framed in terms of lexical representation rather than memory systems. Terms such as encoding and consolidation describe the process of storing information in memory. The terms used here describe purely lexical processes.

3.1.1 Assessment of the lexical development process

In general, tasks involving recall or recognition of new words shortly after learning typically assess lexical configuration, as these can be performed using form-related traces. In contrast, lexicalization can be evaluated through tasks that allow to assess whether a novel word is influencing the lexical system or if its caracteristics are more readily recognized over time. Such tasks normally involve reaction times, to observe facilitation or competition effects across time. For example, in their seminal study, Gaskell and Dumay (2003) found that newly learned pseudowords (e.g., *cathedruke*), acquired through a phoneme-monitoring task in which participants repeatedly indicated the presence or absence of a specific phoneme within a target, interfered with the recognition of phonologically similar existing words (e.g., cathedral) in a

lexical decision task (RTs were longer). This lexical competition effect was interpreted as evidence of lexicalization.

In their study, Leach and Samuel (2007) conducted five experiments to evaluate not just the final stage, but the entire lexical development process, from configuration to lexicalization, in adults. First, they chose optimal measures of lexical configuration and lexicalization (Experiment 1). Then, they compared the effects of different learning conditions on both lexical statuses (Experiments 2-5). In Experiment 1, they used the same learning paradigm as Gaskell and Dumay (2003) – phoneme monitoring – and employed two recognition tasks (forced choice and word-in-noise recognition) to assess configuration and two perceptual tasks (phonemic restoration and perceptual learning) to assess lexicalization. Leach and Samuel found that the training regime produced strong evidence of lexical configuration but weak evidence of lexicalization. This was considered initial support for the theoretical distinction in which information about each new word can be represented without meeting the criteria required to behave as an integrated lexical item.

In Experiment 2, they used picture association training instead of phoneme monitoring to learn words. This picture association training led to configuration and lexicalization, as measured by the word-in-noise recognition and perceptual learning tasks, respectively. In the word-in-noise task, words are hidden behind gradually diminishing white noise, and participants indicate when they recognize the word. Recognizing the word at higher levels of noise indicates stronger configuration. The perceptual learning task measures the ability of learned words to change sublexical categories (see Norris et al., 2003). Thus, the argument is that if a novel lexical item is able to produce changes to a sublexical level, it is because it has been lexicalized.

At this point, Leach and Samuel hypothesized that semantic information might play a critical role in promoting lexicalization. Although picture association training produced it

relative to phoneme monitoring, it remained unclear whether this advantage stemmed from the presence of meaning, from the explicit associative demands of the task, or from another factor. In Experiment 3, they replaced picture association with a story-based learning context in which participants encountered novel words embedded in meaningful narratives. The results revealed a moderate level of lexicalization, stronger than that observed following phoneme monitoring, but weaker than that produced by picture association. These findings led them to suggest that semantic information facilitates integration, but that the active and intentional learning demands of picture association may further strengthen functional lexical representations.

The authors also considered whether production could improve integration. In Experiments 4 and 5, participants were required to produce the novel words repeatedly within the phoneme-monitoring or picture-association paradigms. The addition of production led to good configuration and, contrary to their expectations, a worsening of lexicalization. They proposed that the additional production requirement may have overwhelmed cognitive resources, thereby reducing encoding quality and hindering integration, as measured by their lexicalization task.

Essentially, Leach and Samuel conclude on the importance of distinguishing between grasping the form of a new word and the process by which a representation becomes a fully functional lexical entry in order to better understand lexical development. Furthermore, they highlight that semantic information produces representations that interact more readily with existing lexical knowledge. Furthermore, they argue that while perceptual tasks require restructuring sublexical categories, lexical competition can be more easily observed through the comparison with already existent lexical entries, leaving the lexical competition as the most suitable for studying lexicalization. Finally, they considered the production results in terms of the influence that encoding conditions can have on the resulting lexical representations.

Overall, the current research agenda adheres to their suggestion that when examining lexical developmment "one cannot simply ask 'How is a word added to the mental lexicon?'. A more appropriate question would be 'What learning conditions lead to the development of lexical configuration information, and what conditions promote *lexicalization*?'" (Leach & Samuel, 2007, p. 345). In this work, two of our studies investigated whether the learning modality condition would provide insight.

Interest in the role of modality on lexicalization arose because word learning involves integrating at least three aspects of lexical knowledge (orthography, phonology, and semantics), and novel words are always encountered in context, whether orally or through written text (K. Nation, 2017). Indeed, context is important to the extent that, according to Leach and Samuel (2007), lexicalization occurs more readily for new words with a referent among known words than for building such representations from scratch. This conclusion was drawn from observations showing that training with semantics (via picture associations or full stories) produced much stronger evidence of lexicalization.

Such relevance of semantic information is in line with studies showing that semantic representations play an important role in lexicalization of novel words (Henderson, Weighall, & Gaskell, 2013; Hulme et al., 2019; Smejkalova & Chetail, 2022). In an interesting study with children, Henderson and colleagues (2013) found that when children were exposed to the meanings of real science words (e.g., hippocampus) through images and definitions during training, they recalled the words better and took longer to detect pauses in existing words (e.g., hippopotamus) after 24 hours. This study, along with Henderson et al. (2012), was one of the first to provide evidence that lexical competition, and therefore lexicalization, occurs in children. However, as with most studies interested in lexicalization, the main modality was auditory for both training and testing.

Indeed, in both of their studies, Gaskell and Dumay (2003) and Leach and Samuel (2007) used speech for presenting their stimuli during learning and during testing. Although Leach and Samuel (2007) used images and stories during learning in some of their experiments. Subsequent studies only use tasks involving phonological processing (e.g., phoneme monitoring) during exposure (Davis et al., 2009; Dumay & Gaskell, 2012; Henderson, Weighall, Brown, et al., 2013; Tamminen & Gaskell, 2008; Weighall et al., 2016). Similarly, lexicalization is primarily evaluated through oral recognition of competitors or identification of the meaning or corresponding image of the learned words via speech. For instance, Weighall (2016) used the Visual World Paradigm to study the time course of lexicalization in adults and children. The researchers taught participants different pseudowords that matched their phonological form to images. Then, they observed how the participants' gaze shifted toward the novel lexical items when hearing existing words. The results showed that lexicalization takes longer in children than in adults when measured with this paradigm (see also Kapnoula et al., 2015). While the experiment provided insight into the time course of lexicalization in both populations, it is unclear whether all word features (orthographic, phonological, and semantic) were integrated or if it is instead a matter of strong association between the oral form and the image.

Only a few studies have examined the lexicalization of orthographic and semantic representations using similar approaches (Bakker et al., 2014; Bowers et al., 2005; Clay et al., 2007; Wang et al., 2017). For example, Bowers et al. (2005) trained adults on novel word forms using a typing task and later assessed its impact on recognizing semantically related existing words. They observed lexical competition effects only after a 24-hour delay, which is consistent with findings from most auditory word learning studies. Most importantly, this shows that orthography can also lead to lexicalization in expert readers. In a similar vein, Wang et al.

(2017) demonstrated that a delay is necessary for orthographic information to start interacting with related semantic representations.

In another study, Tamminen and Gaskell (2013) used a priming paradigm to provide evidence of semantic integration. In their study, adults learned pseudowords paired with definitions that were designed to create semantic categorization. The authors used visual masked priming, meaning the participants were unaware that the orthographic forms of the learned words were presented before the targets, on which the participants had to make lexical decisions. According to Tamminen and Gaskell, this minimized the likelihood of strategic processing based on associations while still making it possible to observe whether the novel words had been integrated into lexico-semantic networks. They found that the novel words produced semantic priming. Remarkably, the target words were never presented alongside the pseudowords during the learning phase, which reinforces the idea that the words were lexicalized rather than merely associated during learning.

The only evidence that children exhibit lexical competition effects after orthographic learning, as adults do, comes from an insightful study by Tamura et al. (2017). The authors investigated how quickly children aged 9 to 11 integrate written word forms into their lexicon. They assessed lexical configuration using word recognition tasks (e.g., spelling and lexical decision) and lexicalization using a priming-based lexical competition paradigm. In one of their experiments, the authors manipulated the level of attention drawn to the words and found that exposure to novel orthographic forms embedded in stories led to configuration and lexicalization, regardless of the attentional focus during learning.

Thus, lexicalization has mainly used the oral modality both for learning and testing, although some studies have used written exposure (Bowers et al., 2005; Clay et al., 2007; Wang et al., 2017). In these studies, semantic information was sometimes used for learning but was not assessed. Furthermore, lexicalization has primarily been studied in adults (Bakker et al.,

2014; Davis et al., 2009; Dumay & Gaskell, 2012; Leach & Samuel, 2007; Tamminen & Gaskell, 2008). There are a few studies that have examined it in children but still only using the oral modality (Henderson et al., 2012; Henderson, Weighall, Brown, et al., 2013; James et al., 2019; Weighall et al., 2016). Only one study has investigated lexicalization in children after exposure to orthographic forms (Tamura et al., 2017). However, the question remains whether modality might impact the configuration and lexicalization of orthographic, phonological, and semantic representations of novel words.

Chapter 4: Does Modality Impact Lexical Development?

When children are learning to read in an alphabetic language like English, French or Spanish, what they are learning is that each letter or group of letters represents a sound from that language (i.e., the Alphabetic Principle; Byrne, 1998). According to the self-teaching hypothesis (Share, 1995, 2008b) the knowledge of such a principle provides a mechanism that enables to decode, that is, to retrieve the phonological representation of novel words on the basis of those grapheme-to-phoneme correspondences (GPC). Likewise, the acquisition of the alphabetic principle has been observed to impact the processing of spoken words (Ziegler et al., 2004; Ziegler & Ferrand, 1998), meaning that by means of the phoneme-to-grapheme mappings (PGM) orthographic and phonological representations can interact. In short, once the basic letter–sound correspondences are established (e.g., the letter d represents the sound /d/), phonological decoding enables orthographic representations to develop implicitly through exposure to print, which in turn seems to generate the capacity to infer the orthography of a word from its phonological form (Castles & Nation, 2022).

This may help understanding how the quality of lexical representations plays a role on reading and why reading becomes a powerful mechanism for vocabulary growth. The more words a child knows when texts start to demand vocabulary that is not normally found in speech, the easier it will be to decode it, the more they decode because they are exposed to written material, the more words they acquire, which will enrich their capacity to understand and so on (Willingham, 2017). However, not all children engage in reading equally. For those with limited reading experience, the modality through which words are encountered may have different influences for the lexical configuration and potentially for lexicalization of their orthographic, phonological and semantic representations. The current chapter provides an overview of studies that address how spoken and written exposure to novel words may indeed influence the

integration of new words into the lexicon. This will lay the foundations for the two experimental studies presented in Chapter 7.

4.1 Orthographic facilitation and orthographic skeletons

Ehri's theory of word learning (Ehri, 1992) posits that the automatic activation generated by seeing a word's spelling allows for the binding of written and spoken forms. According to her theory, graphemes serve as stable anchors that help clarify phonemic details and provide a visual image of the word, thereby enabling children to form more precise and durable orthographic and phonological representations. This boost in phonological foundation helps to accelerate the integration of semantic information into the lexical representation, which has been supported by studies describing the role of spelling in word learning.

The Orthographic Facilitation Hypothesis suggests that presenting a word's written form along with its pronunciation enhances the acquisition of its phonological form and the retention of its meaning in memory (Ricketts et al., 2009; Rosenthal & Ehri, 2008). Rosenthal and Ehri's (2008) found that second and fifth graders learned and remembered the pronunciations and meanings of new words more effectively when shown the written form during learning sessions than when only hearing and repeating the words. In a subsequent study, Ricketts et al. (2009) obtained similar results for the learning of nonwords using a paired-associate paradigm. Since then, the orthographic facilitation (OF) effect has been widely replicated in numerous studies (Chambré et al., 2017; Jubenville et al., 2014; Salins et al., 2023; see Colenbrander et al., 2019 for a review), and has contributed to understand the role of orthography in word learning, even in L2 (Krepel et al., 2021; Salomé et al., 2024), as well as informed effective educational practices in vocabulary teaching.

In these studies, however, participants typically encounter two conditions while learning, one in which only the spoken form is presented (orthography-absent, O-P+) and one in which both the spoken and written forms are presented simultaneously (orthography-present, O+P+).

Given these conditions, it is difficult to determine whether the observed advantage is due to the written modality specifically or to the availability of complementary, simultaneous information when comparing a double-information condition (OP) with a single-information condition (P).

One explanation for the OF effect during word learning is that orthography acts as a mnemonic device, enabling more stable retention of relevant information about a word than phonology does (Ehri, 2005b, 2014; Rosenthal & Ehri, 2008). Another possibility, proposed by Ricketts and colleagues (2009, 2021; Colenbrander et al., 2019), is that OF is prompted by the alphabetic principle. This explanation is appealing, given the relationship between letters and sounds in alphabetic languages. However, see Li et al. (2016) for an example in a non-alphabetic language. According to this idea, the degree of consistency in GPCs could moderate the OF effect. Thus, if the stimuli are consistent, orthography will be a more reliable cue to phonological and semantic representations of words (Ricketts et al., 2021).

In their original study, Ricketts et al. (2009) not only controlled for the presence or absence of orthography during oral word learning, but also manipulated the GPCs. They found that orthography benefited the learning of both consistent and inconsistent words as measured by word-image matching. However, they found that orthography significantly improved the production of inconsistent spellings. These results suggested that orthographic facilitation may be particularly helpful when spelling patterns are difficult to infer from phonology alone, as is often the case in English.

In a further study, Jubenville et al. (2014) examined whether orthographic consistency moderates the orthographic facilitation effect during word learning in French. They used a larger number of items and learning trials than Ricketts et al. (2009) did because they believed the absence of interaction between orthography and consistency in Ricketts et al.'s word-image matching task was due to insufficient statistical power. They tested both monolingual and bilingual children and found that consistency affected orthographic facilitation differently.

French-speaking monolingual children showed more orthographic facilitation for consistent items, whereas French-English bilinguals showed more orthographic facilitation for inconsistent items. Which suggests that consistency may modulate the OF effect.

In a more recent study, Ricketts et al. (2021) further evaluated whether consistency in the GPC moderates the orthographic facilitation effect. Using more precise measures of word learning than in previous studies, they found no interaction between orthography and consistency. These mixed findings leave open the question of whether orthographic consistency interacts with orthographic facilitation. According to Ricketts et al., orthographic learning may be similar in both conditions for two reasons. First, an effect of saliency may exists for inconsistent items, meaning that the orthography of hard-to-spell words makes them more memorable, which is in line previous accounts (Jubenville et al., 2014). Conversely, consistent items may already have a strong orthographic representation from speech because it is easy to map their sounds to letters. This is consistent with the previous discussion about the impact of orthography on speech and can be explained by a complementary account described below.

The Orthographic Skeleton Hypothesis (Wegener et al., 2018) proposes that learners generate expectations about the orthographic form of a spoken word based on knowledge of phoneme-to-grapheme mapping. This allows learners to predict a word's likely spelling before seeing it in print. Both adults (Jevtović et al., 2022, 2023) and children (Beyersmann et al., 2022; Wegener et al., 2018) have been observed to generate orthographic skeletons (OS), even in the case of irregular PGM (i.e., more than one mapping for one sound) (Jevtović et al., 2022) and in the absence of contextual information (Wegener et al., 2023). Furthermore, these inferred orthographic forms have been found to facilitate subsequent recognition when the written form is encountered later (Jevtović et al., 2023).

This idea is explained in the seminal study by Johnston et al. (2004), who showed that orally learned words primed written words presented for the first time in a masked priming

paradigm. Importantly, their third experiment showed that the priming effect remain stable across testing blocks for the novel words, resounding with the need of time for lexicalization and suggesting, as the authors proposed, that a more detailed or semantic analysis might be necessary for these representations to reach the specificity (i.e., lexical quality) observed for familiar words.

Building on this, Wegener et al. (2018) evaluated the capacity of children to predict the orthographic skeletons of nonwords presented orally. Participants were first taught the pronunciation and meanings assigned to each item and then were asked to read sentences including both trained and untrained materials while their eye movements were recorded. When trained words appeared with predictable spellings (e.g., the spoken word /ne/ʃ was written as nesh), reading times were shorter than when they appeared with unpredictable spellings (e.g., the spoken word /kɔɪb/ was written as koyb). The authors interpreted this as evidence that expectations about the spelling are generated and activated before any visual exposure to print. Subsequent work has replicated and extended these findings in both children (Beyersmann et al., 2022) and adults (Jevtović et al., 2022), indicating that orthographic expectancy mechanisms operate across development and reading proficiency levels.

In a further insightful study, Wegener and her team (2023) provided compelling evidence that orthographic skeletons can form even when words are presented in isolation, without supporting sentence context. Using the same predictable and unpredictable stimuli as in Wegener et al. (2018), they trained adults on novel words orally and later tested them in a lexical recognition task. Results showed that recognition latencies were shorter for trained predictable items compared to both untrained and unpredictable items. Crucially, this effect emerged even when nonwords were presented in isolation, what makes the phenomenon measurable using lexical competition tasks.

The possibility of acquiring phonological forms from orthography and generating orthographic expectations from phonology can be explained by models assuming interaction between sublexical units when encountering a new word (Grainger et al., 2005). Therefore, these phenomena can be studied using the configuration and lexicalization framework. However, it may be worthy to highlight that French is a language with a particular orthographic system. Its GPCs are quite consistent because each grapheme corresponds to a predictable phoneme (e.g., eau is always pronounced /o/). In contrast, its PGMs are rather irregular because one phoneme can be mapped to multiple graphemes (e.g., the sound /o/ can be written in more than five ways). Ziegler et al. (1996) estimated that French has 12.4% of inconsistent GPC while PGM are irregular to a rate of 76%. For comparison, English has a high number of both (72% and 49%, respectively) (Stone et al., 1997). These differences may affect language processing (Ziegler et al., 2003, 2004; Ziegler & Ferrand, 1998), possibly impacting also the advantages of orthography and the emergence of OS. While the latter highlights phoneme-to-grapheme correspondences, the OF highlights the reverse process, grapheme-to-phoneme mappings are the ones that strengthen word representations. All this is worthy to mention because both phenomena have been observed primarily in English and thus a study that helps to see how these processes happen in a different language can be worthy.

4.2 Visual vs. oral presentation studies

Several studies have examined the effectiveness of different learning modalities for acquiring vocabulary, in both children (Melamed et al., 2024; Suggate et al., 2013; Valentini et al., 2018) and adults (Bakker et al., 2014; J. Nelson et al., 2005). The results with children are ambiguous. For example, Valentini et al. (2018) trained 8- and 9-year-olds using stories containing novel words under three conditions: listening only, reading only, or simultaneous listening and reading. Through recognition tasks, Valentini et al. discovered that children in the reading group benefited from orthographic information to develop phonological

representations, comparable to those in the auditory group. However, children in the auditory condition did not seem to acquire orthographic representations based on phonological information. The simultaneous condition led to better performance in a category recognition task, indicating that it was more effective for acquiring semantic representations. These results are somewhat consistent with those of Suggate et al. (2013), who compared children's word learning in three conditions similar to those of Valentini et al. Suggate observed that children who listened to stories were more likely to acquire knowledge of the meanings of new words than children who read the stories. Based on these results, the authors suggested that oral presentation is more beneficial than written presentation for vocabulary learning in school-aged children.

In a more recent study, Melamed et al. (2024) examined how auditory and written modalities impact the ability of children aged 8 to 15 to infer meanings. Written input alone led to better recall across ages, with greater benefits for those with higher reading proficiency and larger pre-existing vocabulary. Taken together, these findings suggest that orthographic input alone, compared to oral modality, is enough word learning as literacy develops. However, given the immediate testing in all the studies, their measures likely reflect associative relationships between word forms and their meanings, but not their lexicalization. Something to highlight is that the three studies embedded novel words within meaningful contexts, without directing children's attention to specific linguistic features, reflecting naturalistic learning. Yet, they relied solely on recognition and recall tasks, typical measures of lexical configuration, and only immediately after exposure. Lexicalization requires time, as we saw in Chapter 3, and is best assessed with tasks capturing lexical effects over time.

Concerning the studies with adults, Nelson et al. (2005) found faster learning and better recall for words learned in the written modality using semantic exposure (i.e. presentation of the meaning). In contrast, Bakker et al. (2014) found that both modalities supported lexical

competition after 24 hours when learning and testing were congruent. Cross-modal transfer also emerged in both modalities, but with different time courses, orally learned words generalized to the visual modality after 24 hours, whereas words learned through print only generalized to speech after one week, suggesting a time advantage for speech input to generate word form representations. Which indicates that there is also some ambiguity that may stem from methodological differences. Bakker et al. focused on phonological processing, whereas Nelson et al. emphasized semantic learning, which likely enhanced memory integration. To more clearly evaluate which modality best supports vocabulary development, it is important to avoid training regimes that bias learning toward specific aspects of words.

Chapter 5: Summary and Research Gaps

The research reviewed in the previous chapters highlights several aspects that are central to the studies presented in this thesis. First, research consistently shows that vocabulary development is influenced by a variety of factors. These include individual cognitive characteristics as well as environmental conditions that impact children's language exposure. Among environmental factors, SES has been consistently identified as a major determinant of differences in vocabulary development (Buckingham et al., 2013; Ma et al., 2024). Children growing up in lower socioeconomic contexts are often exposed to fewer linguistic interactions and may encounter a more limited diversity of words in everyday communication (Rowe, 2012). In addition, access to literacy-related experiences, such as shared book reading, independent reading opportunities, and exposure to written language in the home environment, may vary substantially across socioeconomic contexts (Hoff, 2013). These differences in both the quantity and quality of linguistic input contribute to disparities in vocabulary development from the earliest stages of schooling and beyond (Hart & Risley, 2003; Lervåg et al., 2019).

Second, the literature emphasizes that vocabulary cannot be understood only in terms of the number of words known. Rather, vocabulary knowledge should comprise at least two complementary dimensions: breadth and depth (R. Anderson & Freebody, 1981; Ouellette, 2006). Vocabulary breadth refers to the number of lexical items that an individual knows, while depth reflects the richness and quality of knowledge associated with those words, including then detailed knowledge of a word and strong connections with other lexical items. Depth of vocabulary has been identified as critical for language comprehension (Cain & Oakhill, 2014; Ouellette, 2006; Tannenbaum et al., 2006) and therefore could be related to the Lexical Quality Hypothesis (Perfetti & Hart, 2002). According to this hypothesis, words with well-specified phonological, orthographic, and semantic properties that are strongly interconnected within the

mental lexicon form high-quality lexical representations which can be accessed and retrieved more efficiently, for example, during reading comprehension (Perfetti & Stafura, 2014).

Third, research on word learning suggests that lexical development can be described as involving at least two distinct processes (Leach & Samuel, 2007). The first corresponds to lexical configuration, in which a learner acquires the general information about a new word and establishes its representations. This stage can typically be measured through tasks assessing recognition or recall of recently encountered items. The second process involves lexicalization, that is, the progressive integration of the new word into the existing lexical system. Once lexicalized, the word begins to interact with other lexical entries, producing measurable lexical effects such as priming effects (Tamminen & Gaskell, 2013) or competition during recognition of existing words (Gaskell & Dumay, 2003).

Finally, previous studies indicate that the modality through which a word is first encountered may influence the early stages of lexical development. In particular, modality appears to affect lexical configuration, as written and spoken forms may provide different types of information for establishing initial representations (Bakker et al., 2014; Melamed et al., 2024; J. Nelson et al., 2005; Valentini et al., 2018). However, the role of modality in the later process of lexicalization remains less clear.

If lexicalization depends on the strength and quality of the initial lexical configuration and such a process is shaped by the conditions under which words are learned, as shown by Leach and Samuel's (2007) findings, one reasonable question could be whether lexical configuration, and maybe lexicalization, depends on the modality through which a word is initially encountered. This question is particularly relevant to the present research agenda, which takes place in school settings and acknowledges the relationship between word learning and reading development. If the modality through which a word is first encountered influences its lexical development, this could provide insight into how to develop high-quality lexical

representations when children encounter words. While the focus remains on word learning, the broader objective is to identify learning conditions that foster robust lexical knowledge to support vocabulary and, ideally, reading engagement.

In this way, we consider several research gaps, on which our research will focus. First, although socioeconomic differences in vocabulary size are well documented, it remains unclear whether SES also affects the depth and quality of lexical representations. It should be noted that given the context of the current research agenda, our populations concerned mainly children from low SES. Thus, a first study was deemed necessary to gain an overview of these children's vocabulary characteristics. If we want to know what modality leads to stronger lexicalization with eventually higher quality lexical representations, it is necessary to understand the status of the characteristics of children's vocabulary not only considering breadth but also depth that is quite related to lexical quality, as we could see in Chapter 2.

Second, the role of learning modality in the lexical development process, especially for lexicalization, remains insufficiently understood. Some studies have addressed modality effects in vocabulary learning (Bakker et al., 2014; Melamed et al., 2024; J. Nelson et al., 2005; Valentini et al., 2018; Van Der Ven et al., 2015), this body of research – except for Bakker et al. (2014) – has not considered the lexical integration models and often relies on immediate recognition tasks.

In Chapter 4, we saw that word's orthography along with its phonology is particularly helpful to children for acquiring word forms (i.e., Orthographic Facilitation; Ricketts et al., 2009). Furthermore we saw that when children hear novel words, they can generate orthographic representations based on their knowledge of the phoneme-grapheme mappings (i.e., Orthographic Skeletons Hypothesis; Wegener et al., 2018). If we consider the bimodal activation model (Grainger et al., 2005), it is possible to understand how orthography facilitates the acquisition not only of orthographic but also of phonological representations and how it is

possible to generate orthographic representations from phonology. However, as discussed before, in most of the studies about OF, phonological and orthographic information is presented simultaneously, making it difficult to determine the independent contribution of each modality. This can make the question arise of whether lexical development differs when words are first encountered in oral form compared to written form. Especially in a language like French that has an orthographic system with rather consistent grapheme-phoneme correspondences and highly irregular phoneme-grapheme mappings.

Third, most studies investigating the integration of novel words into the lexicon have focused on auditory-learning paradigms. Starting with Dumay and Gaskell (2003) and Leach and Samuel (2007), experimental protocols have mainly involved phonological training, sometimes accompanied by visual information such as images, but rarely involving written forms of the words. Furthermore, whether studies with adults (Dumay & Gaskell, 2007; Lindsay & Gaskell, 2013; Takashima et al., 2017; Tamminen et al., 2010; Tamminen & Gaskell, 2008) or whith children (Henderson et al., 2012; Henderson, Weighall, & Gaskell, 2013; James et al., 2019; Weighall et al., 2016), authors have evaluated lexicalization using mainly oral tasks. Although some work has explored orthographic or semantic learning in adults (Bowers et al., 2005; Clay et al., 2007; Tamminen & Gaskell, 2013) it is just recently that a few studies have turned towards children (Henderson et al., 2012; Henderson, Weighall, & Gaskell, 2013) with even less in a different modality than the oral one (Tamura et al., 2017; Wang et al., 2017). This opens the way to consider the possibility of comparing the effects of modality on lexicalization.

Finally, such studies have been conducted under highly controlled laboratory conditions, meaning that participants are typically seated individually at a computer and exposed repeatedly to novel items until a predetermined learning threshold is reached. In auditory training paradigms, participants frequently wear headphones. Moreover, most of these studies rely on pseudowords in order to ensure that adults, the common population in these types of studies,

do not possess prior knowledge of the stimuli. While this approach offers strong experimental control, it does not necessarily reflect the conditions under which vocabulary is typically acquired in real-life contexts. In everyday experience, words are learned gradually, often through meaningful interactions, via reading or listening to someone. Although some studies with children have demonstrated lexicalization following pseudoword learning in the auditory modality (Henderson, Weighall, & Gaskell, 2013; James et al., 2019; Weighall et al., 2016), investigating lexical development using real words in school-aged children may broaden our understanding of word learning and contribute to educational practices aimed at fostering vocabulary growth.

This thesis presents a research agenda that seeks to address those questions. Specifically, the studies reported here aim to contribute to our understanding of vocabulary and word learning in primary school children by situating the investigation within real classroom environments.

The next three studies were conducted in French public schools within the framework of a national research initiative. This institutional context enabled collaboration with teachers in French public schools, and the opportunity to conduct experimental protocols directly in classroom settings. Carrying out the studies in authentic educational environments allowed the research to remain closely connected to everyday learning practices while maintaining experimental control. The theoretical objectives that guided the research program and the hypotheses associated with each study are presented below.

5.1 Theoretical objectives and hypotheses

The general aim of this thesis was to deepen our understanding of vocabulary and word learning processes in primary school children, with a particular focus on how different learning modalities may shape the mechanisms supporting word learning. In doing so, this research seeks to contribute both to the broader field of language and literacy research and to ongoing

discussions surrounding evidence-based approaches to vocabulary instruction in educational contexts.

Three main research objectives guided the studies presented in this thesis:

1. To examine whether SES impact differently on the two dimensions of vocabulary knowledge (breadth and depth).
2. To investigate the impact of oral and written learning modalities on word-learning trajectories, from initial lexical configuration to later lexicalization.
3. To characterize how orthographic, phonological, and semantic representations emerge across learning modalities and evolve over time.

These objectives were addressed through three experimental studies.

5.1.1 Study 1: SES and Dimensions of Vocabulary Knowledge

The first study, presented in Chapter 6, aimed to examine whether SES influences not only vocabulary breadth but also vocabulary depth.

Previous research has consistently documented differences in vocabulary size across socioeconomic groups (Hart & Risley, 2003; Hoff, 2003; Neuman et al., 2018). These differences are commonly attributed to variations in linguistic input during development, including both the amount of language children are exposed to and the diversity of lexical items encountered in everyday interactions. Children from higher socioeconomic backgrounds are more likely to experience rich language environments characterized by frequent conversations, varied vocabulary, and greater exposure to literacy activities such as shared reading (Hoff, 2006; Rowe, 2012).

However, most studies examining SES differences in vocabulary rely on measures that primarily assess vocabulary breadth, such as standardized tests of word knowledge. Much less is known about whether SES also affects the depth of lexical knowledge, that is, the richness and interconnectedness of lexical representations. Given the consistent differential participation

of vocabulary breadth and depth on reading outcomes (Cain & Oakhill, 2014; Ouellette, 2006), it is plausible that differences in vocabulary exposure may influence not only the number of words children know but also the quality of their lexical representations.

We therefore compared children's vocabulary breadth and vocabulary depth as a function of SES. Vocabulary breadth was assessed using standardized measures of the number of words known, while vocabulary depth was evaluated through tasks targeting detailed knowledge of lexical representations.

Based on previous literature, it was expected that SES would affect vocabulary breadth. More importantly, we hypothesized that SES might also influence vocabulary depth, reflecting an effect on the richness and interconnectedness of lexical representations, beyond the number of words known.

5.1.2 Studies 2 and 3: Learning Modality and Lexical Development

The second and third studies, presented in Chapter 7, focused on the role of learning modality in lexical development. These studies investigated how words learned through different modalities (spoken and written) develop over time, from initial lexical configuration to later lexicalization.

To examine these processes, children were trained on real words under different learning conditions, systematically controlling for exposure modality. Their knowledge of the newly learned words was assessed immediately after training, in order to capture lexical configuration, and again one week later, evaluating lexicalization. In this way, we intended to track the development of orthographic, phonological, and semantic representations across time and learning conditions.

5.1.2.1 Study 2: Comparing Oral and Written Learning Modality

The second study examined how oral and written modalities contribute to word learning. Previous research suggests that orthographic information may play a particularly important role

in word learning once children have acquired basic reading skills (Cunningham, 2005). Written forms can provide stable visual representations that support the establishment of lexical representations and facilitate the identification of word structure (Ricketts et al., 2009; Rosenthal & Ehri, 2008). For this reason, orthography has often been found to support the acquisition of new vocabulary in children who have already mastered reading.

Based on this literature, it was expected that visual exposure through written material would lead to stronger lexical configuration compared to oral exposure alone. Written forms may help learners capture the structure of word forms more efficiently, supporting the early establishment of orthographic and phonological representations.

Regarding lexicalization, there is no theoretical reason to assume that words learned through one modality would become integrated into the lexicon while words learned through another modality would not. Words are naturally acquired through both spoken and written language. However, it was expected that words learned with orthographic support might show stronger lexicalization effects, reflected in greater improvements over time and more robust lexical effects such as increased competition or faster recognition latencies.

5.1.2.2 Study 3: Comparing Written vs. Sequential Written and + Oral Input

While the second study examined the contributions of oral and written modalities separately, the third study aimed to further investigate the specific role of phonological information in word learning. To address this question, the study compared two learning conditions. In one condition, children learned words through written input alone. In the other condition, children were first exposed to the phonological form of the word, followed by its written form, creating a sequential phonology–orthography learning condition. The objective of this design was to isolate the potential contribution of phonological pre-exposure and determine whether presenting the phonological form before the written form could facilitate the establishment of lexical representations.

Given the limited evidence addressing this specific question and the unpredictability of PGM in French, it was difficult to make precise predictions about the exact contribution of phonological pre-exposure. However, it was reasonable to expect that exposure to both modalities would strengthen lexical representations more than orthographic exposure alone.

Together, these three studies aim to contribute to a better understanding of how vocabulary knowledge develops in children, how environmental factors such as SES may influence lexical representations, and how learning modalities shape the processes through which new words become integrated into the mental lexicon.

SECTION 2

EXPERIMENTAL CONTRIBUTION

Chapter 6: Impact of SES on Breadth and Depth of Vocabulary

This chapter revisits the content of an article published in the *Journal of Child Language* under the title "***Beyond breadth of vocabulary: vocabulary depth can also be impacted by school's socioeconomic status***" (Vargas-Cuevas, Facon, et al., 2026).

6.1 Study context

As we could see in Chapter 1, evidence indicates that students from lower SES backgrounds often present poorer academic outcomes than their peers from higher SES backgrounds (Schoon et al., 2012). These differences can be largely attributed to disparities in early language exposure, as children from low-SES families typically experience less frequent and less diverse linguistic input (Hoff, 2003). As we saw in Chapter 2, both breadth and depth of vocabulary impact on word learning capacity, but depth seems to be a particularly important factor when it comes to acquiring new vocabulary and understanding text. Since such disadvantage reduces the opportunities for knowledge-building and literacy development, resulting in impoverished language-related capacities, including vocabulary itself (Cain et al., 2003), a closer look at how SES can affect vocabulary was deemed necessary.

There is plenty of evidence showing the impact of SES on vocabulary capacity (Fernald et al., 2013; Hoff, 2003, 2006; Ma et al., 2024; Neuman et al., 2018). However, in studies reporting vocabulary outcomes, what is most often assessed is the number of lexical items known or the rate of vocabulary growth (Schmitt, 2014; Webb, 2012; Yanagisawa & Webb, 2019). This means that the tasks used primarily focus on links between the form, either oral or written, and the meaning of a word. For example, Neuman et al. (2018) reported that children from low-income families were exposed, both in their families and their schools, to poorer language in terms of content and quantity, in comparison to their peers from higher-income families. They provided evidence that children from lower-SES showed lower performance in vocabulary tests. The differences were remarkable in both receptive vocabulary, measured by

the Peabody Picture Vocabulary Test-IV (PPVT-IV) (Dunn & Dunn, 2007), and expressive vocabulary, measured by the Woodcock-Johnson III-Picture Vocabulary subtest (WJIII-PV) (Woodcock et al., 2007).

Importantly, these tests require children to match images to words. While they provide information on the number of words a child associates with a concept, they do not indicate how well those words are known. The distinction between knowing a word and knowing it well is captured by the distinction between vocabulary breadth and depth. When this distinction was outlined, in Chapter 2, in terms of the number of words someone knows and their detailed knowledge of word meanings (R. Anderson & Freebody, 1981), it was noted that breadth of vocabulary is usually easier to assess than depth of vocabulary.

Measuring vocabulary breadth is more straightforward because it involves measuring the ability to link a word to its meaning. This makes it possible to infer the number of words for which there is a referent in someone's lexicon. Standardized tests that require matching an image with a word generally provide this information. In contrast, evaluating vocabulary depth has proven more difficult. Previous studies have used word definition tasks or tasks that demonstrate the depth of knowledge of a word and its relationship to other words (see Chapter 2).

In the study presented here, we used the Picture Designation Task, from the battery to assess written and oral language (EVALEO in French) (Launay et al., 2018), to evaluate breadth of vocabulary. Furthermore, we adapted our measures of depth of vocabulary. We did so for two main reasons. First, because our study was carried out in French. Most studies on the impact of SES in children's vocabulary are conducted in English and focus primarily on academic vocabulary or clinical populations (Deane et al., 2014; Schmitt, 2014; Webb, 2012). Second, as discussed above, existing instruments tend to emphasize vocabulary size, while tools

specifically designed to assess depth are less readily available, particularly for French-speaking children.

Moreover, some studies have also shown that when using standardized tests to evaluate differences in knowledge in children, those differences can be amplified because of the type of words used in those tests, with academic words showing more disadvantage than non-academic words (Castles et al., 2018; Marulis & Neuman, 2010; Wright & Cervetti, 2017). In such cases, low-SES children may not reflect a lack of word knowledge per se, but rather a mismatch between the words children know and those targeted by the tests.

6.2 Research question

Children from low-SES backgrounds may be at a disadvantage in building high quality lexical representations, and this might be due to their lack of vocabulary. Although previous research indicates a negative effect of SES on vocabulary, the measures employed in these studies predominantly target vocabulary size. Given the distinction between knowing a word (vocabulary breadth) and knowing it well (vocabulary depth), it remains unclear whether SES affects vocabulary depth to the same extent as it affects vocabulary breadth (Neuman et al., 2018). Our study addressed this question in 4th and 5th graders. More precisely, we wondered whether the SES relationship to vocabulary depth, if it exists, is direct or is mediated by vocabulary breadth.

6.3 Method

6.3.1 Participants

Participants were 219 fourth and fifth graders (9 to 11 years old) from five low and average-SES schools in France, all of whom spoke French as their primary language. Due to missing data, analyses were conducted on 212 participants (M=10 years, SD= 0.62).

Since the participating schools in this study differed in IPS values and there was a different number of children per school, it was not appropriate to use IPS as a continuous

grouping factor. Instead, the REP classification was used to define the two student groups. Three schools in the REP category comprised the low SES group (M IPS= 70.8; n=132, coded as 0) while two schools outside this category comprised the average SES group (M IPS= 115; n= 80, coded as 1).

Informed consent was obtained from the children's legal guardians. A simplified letter was used in order to ensure comprehension (see Appendix 1). Oral assent was secured from the children before the assessment started, with the option to withdraw at any time. Teachers confirmed that participants had no learning, cognitive, sensory (e.g., uncorrected visual or hearing impairments), or psychiatric disorders, based on their access to student records and regular interactions. This study was approved by the Ethical Committee (Ref. 2023-730-S120) and complied with the EU General Data Protection Regulation (GDPR) under the supervision of the Data Protection Official (DPO, Ref. 2025-028) at Lille University. It adheres to the ethical principles outlined in the Declaration of Helsinki.

6.3.2 Vocabulary Assessment

1. **Self-Assessment of Vocabulary Knowledge**. This is an adaptation of a task developed by Wesche and Paribakht (1996). It consisted of a scale ranging from 0 to 15 that children used to indicate how well they believed they knew certain words they heard. The stimuli included twenty words drawn from the Manulex database (Lété et al., 2004). Word frequencies ranged from 3.03 to 493,3 occurrences per million, based on data for students in third to fifth grade (8 to 11 years old). The objective of the task was to gather information about the depth of knowledge of everyday vocabulary, allowing children to indicate varying degrees of familiarity with the words.
2. **Attributes**. We adapted the attributes subtest from the Lexical Processing Test - Revised (Richard & Hanner, 1995). In the original version, participants are asked

to describe a noun by providing specific features of the object. In our experiment, in each trial of this task, children were presented with a word accompanied by four or five written descriptions. Examples of possible attributes included function, components, color, size, shape, category, and composition. Some descriptions accurately corresponded to the target word, while others did not.

Children's task was to select the descriptions that corresponded to the presented words. For each word, there were at least one and at most three accurate descriptions. In total, children could obtain 44 points maximum. The odd number of descriptions and accurate matches was deliberately chosen to prevent children from adopting any systematic strategy when selecting attributes. The words used in this task were the same as those included in our Vocabulary Knowledge Self-Assessment task (Appendix 2).

3. **Synonyms**. Based on the synonyms subtest of the Test of Word Knowledge (Wiig & Secord, 2012), we selected a class-matched exercise in which children read a text containing underlined words. For each underlined word, they had to select the synonym from a list of three possibilities.
4. **Picture Designation Task**. To measure vocabulary breadth, we used the picture designation task from the EVALEO 6-15 test battery (Launay et al., 2018). In this task, children heard a word and were required to select the corresponding image from four options. There were 42 stimuli in total, with each item scored out of a maximum of 4 points, resulting in a total possible score of 168.

One minute word recognition task. We designed a one-minute word recognition task using a list of words and pseudowords to control for potential reading differences between groups. The words were chosen from the Manulex database (Lété et al., 2004) with an average frequency of 20 occurrences per million. The pseudowords were

chosen from the pseudowords lists proposed in the EVALEO battery. A list of 100 words and pseudowords mixed in four columns were printed. Children were instructed to read them silently within a minute (Appendix 3). They had to cross out the pseudowords. The number of correctly recognized words within the time limit was considered.

The Self-Assessment of Vocabulary Knowledge, the Attributes Task and the Synonyms Task reflected depth of vocabulary knowledge while the Picture Designation Task provided information about breadth of vocabulary. Furthermore, we measured rapid word recognition to control for its potential impact on performance in the Attributes and Synonyms Tasks. All tasks, except for the Picture Designation Task, were specifically designed for this experiment.

6.3.3 Procedure

At the beginning of the experiment, the main researcher introduced himself and distributed a booklet containing all the tasks. The tasks were administered in pencil-and-paper format to the entire class simultaneously. The experiment took place in the children's usual classroom and was completed in a single session lasting around 45 minutes. The tasks were presented in a fixed order within the booklet, identical for all participants.

The session began with the Self-Assessment of Vocabulary Knowledge Task, followed by the Picture Designation Task. Next, participants completed the Attributes Task, and finally, the Synonyms Task. Both the teacher and the researcher ensured that children would not preview the word list for the recognition task, located on the last page. Once all children had finished the Synonyms Task, the researcher carefully explained the word recognition task and started the timer. After all tasks were completed, the researcher collected the booklets and concluded the session.

6.4 Results

Descriptive statistics are reported in Table 1. Reliability estimates were good for the attributes task (ω= .874), and acceptable for picture designation (ω= .739) and self-assessment (ω=.785). Internal consistency was not applicable to the synonyms task as scoring was based on the total performance rather than individual item responses. Nonetheless, previous research on similar subtests reports reliability coefficients ranging from .84 to .93 (Wiig & Secord, 2012).

Table 1

Descriptive statistics for average- and low-SES groups' performance on vocabulary breadth and depth measures and word recognition

Task	Low-SES		Average-SES		Total	
	M (SD)	Range	M (SD)	Range	M(SD)	Range
Breadth of Vocabulary						
Picture Designation	33 (3.89)	19–40	35.4 (3.55)	23–41	33.9 (3.93)	19–41
Depth of vocabulary						
Attributes	32.3 (6.41)	14–42	34.8 (6.41)	18–42	33.3 (6.77)	14–42
Self-Assessment	13.8 (6.84)	6.20–15	14.1 (1.12)	10.20–15	13.9 (1.22)	6.20–15
Synonyms	3.3 (1.35)	0–6	4.3 (1.18)	2–7	3.7 (1.37)	0–7
Reading						
Word Recognition	31.9 (14.53)	9–71	36.2 (15.99)	8–81	33.5 (15.21)	8–81

Note. Picture Designation has a maximum score of 42; Attributes, 44; Self-Assessment, 15; Synonyms, 7; Word Recognition has no fixed maximum.

The normality of distributions was assessed using the Shapiro-Wilk test. Based on the results, log transformations were applied to address significant skewness in the Attributes, Picture Designation, and Word Recognition tasks. After transformation, the normality hypothesis could not be rejected at α=.05 for all variables. Due to pronounced asymmetry, the Self-Assessment variable could not be transformed and was dichotomized (scores < 14 = 0, n = 90; scores ≥ 14 = 1, n = 122). To facilitate interpretation of the regression analyses results, all

test scores were standardized (M = 0, SD = 1). Correlations between test scores and SES are shown in Table 2, all of which were significant at α = .05.

Table 2

Correlation of the standardized variables and SES

Task	SES	Picture Designation	Attributes	Synonyms	Word Recognition
SES	-				
Picture designation	.32	-			
Attributes	.21	.42	-		
Synonyms	.35	.43	.47	-	
Word Recognition	.14	.25	.27	.30	-

Note. All variables were standardized. Correlations are Pearson's r coefficients, all of which were significant at α < .05.

Model comparisons were conducted to assess the fit of linear, quadratic, and cubic regressions for each pair of variables. Of the 30 comparisons performed (10 relationships × 3 models), only two yielded statistically significant improvements. However, the additional variance explained by the more complex models was minimal. Thus, to avoid unnecessary statistical complexity, subsequent analyses were conducted within a linear framework (Cohen et al., 2003, pp. 225–227). Hierarchical regression analyses, presented in Table 3, were conducted to examine the effect of SES on both vocabulary breadth and vocabulary depth, as measured by the attributes and synonyms tasks. In addition, we assessed the extent to which each vocabulary dimension predicted variance in the other. In each model, performance on the word-recognition task was entered as a covariate to control for individual differences in reading.

To evaluate the assumptions underlying the regression analyses, residual diagnostics were systematically conducted. Visual inspection of standardized residuals, together with statistical tests, indicated that residuals did not significantly deviate from normality, revealed no severe outliers, and showed no evidence of heteroscedasticity. The variance inflation factors (VIFs) and condition numbers for all predictors were less than 1.16 and 2.30, respectively, indicating no problematic multicollinearity across analyses. Finally, nonsignificant results on both the Breusch–Godfrey and Durbin's alternative tests suggested the absence of residual autocorrelation in all analyses.

Table 3

Hierarchical regression analyses of breadth and depth variables

Vocabulary Breadth										
Variables	*b*	SE	95% CI for *b*		*t*	*p*	Bootstrapped R^2	ΔR^2	95% CI for bootstrapped R^2	
			LL	UL					LL	UL
Step 1										
SES	0.67	0.13	.41	.94	5.02	<.001	.11	—	.03	.19
Constant	-0.25	0.08	-.42	-.09	-3.08	.002				
Step 2										
SES	0.61	0.13	.35	.88	4.64	<.001	.15	.04	.05	.25
Word Recognition	0.21	0.06	.08	.34	3.24	.001				
Constant	-0.23	0.08	.39	-.07	-2.86	.005				
Step 3a										
SES	0.49	0.13	.24	.74	3.88	<.001	.25	.10	.15	.36
Word Recognition	0.13	0.06	.00	.25	2.02	.045				
Depth (Att)	0.34	0.06	.21	.46	5.36	<.001				
Constant	-0.18	0.08	-.33	-.03	-2.42	.016				
Step 3b										
SES	0.40	0.13	.14	.67	3.03	.003	.23	.08	.13	.33
Word Recognition	0.13	0.06	.00	.25	2.01	.046				
Depth (Syn)	0.32	0.07	.18	.45	4.71	<.001				
Constant	-0.15	0.08	-.31	.00	-1.94	.054				
Vocabulary Depth (Attributes)										
Variables	*b*	SE	95% CI for *b*		*t*	*p*	Bootstrapped R^2	ΔR^2	95% CI for bootstrapped R^2	
			LL	UL					LL	UL
Step 1										
SES	0.43	0.14	.16	.71	3.12	.002	.04	-	-.01	.10
Constant	-0.16	0.08	-.33	.00	-1.91	.057				
Step 2										
SES	0.36	0.14	.10	.63	2.68	.008	.10	.06	.02	.18
Word Recognition	0.24	0.07	.11	.37	3.68	<.001				
Constant	-0.14	0.08	-.30	.03	-1.65	.099				
Step 3										
SES	0.14	0.13	-.12	.41	1.07	.283	.21	.11	.12	.30
Word Recognition	0.17	0.06	.04	.29	2.64	.008				
Breadth	0.36	0.07	.23	.49	5.36	<.001				
Constant	-0.05	0.08	-.21	.10	-0.68	.495				

Vocabulary Depth (Synonyms)										
Variables	*b*	SE	95% CI for *b*		*t*	*p*	Bootstrapped R^2	ΔR^2	95% CI for bootstrapped R^2	
			LL	UL					LL	UL
Step 1										
SES	0.73	0.13	.47	.99	5.50	<.001	.10	-	.05	.20
Constant	-0.27	0.08	-.44	-.11	-3.38	<.001				
Step 2										
SES	0.66	0.13	.40	.91	5.09	<.001	.19	.06	.11	.27
Word Recognition	0.25	0.06	.13	.38	4.04	<.001				
Constant	-0.25	0.08	-.40	-.09	-3.14	.002				
Step 3										
SES	0.47	0.13	.22	.73	3.65	<.001	.26	.07	.17	.36
Word Recognition	0.19	0.06	.07	.31	3.11	.002				
Breadth	0.30	0.06	.18	.43	4.71	<.001				
Constant	-0.18	0.08	-.33	-.03	-2.32	.021				

Note. CI = confidence interval; LL = lower limit; UL = upper limit; Bootstrapped R^2 based on 1,000 bootstrap resamples ΔR^2 = change in R^2. Step 3a adds Depth as measured by the attributes task; Step 3b adds Depth as measured by the synonyms task.

As expected, SES significantly predicted vocabulary breadth, $F(1, 210) = 25.18$, $p < .001$. Importantly, it also significantly predicted vocabulary depth, $F(1, 210) = 9.74$, $p = .002$ for attributes and $F(1, 210) = 30.22$, $p < .001$ for synonyms. Adding breadth improved depth models, $\Delta R^2 = .109$ for attributes, $\Delta R^2 = .078$ for synonyms, while reducing SES effects which, for the attributes task, became non-significant. This suggested a possible mediation effect. For this reason, mediation analyses were conducted using the "Mediate" algorithm with 1,000 bootstrap resamples to ensure robust confidence intervals (see Hayes, 2022, for a discussion of the advantages of this method over the normal theory approach for making statistical inferences about indirect effects).

When assessed by the attributes task, the direct effect of SES on vocabulary depth was no longer significant, indicating that the effect of SES was fully mediated by breadth (Table 4). In contrast, when assessed by the synonyms task, SES remained a significant direct predictor of depth, with a weaker mediation effect by breadth (Table 5). Overall, breadth mediates the relationship between SES and vocabulary depth, with a stronger direct effect of SES on the synonyms task compared to the attributes task.

Finally, the influence of SES on the Self-assessment of Vocabulary Knowledge was evaluated. As self-assessment was a dichotomous variable, a logistic regression analysis was performed. The model yielded an odds ratio of 1.95 (95% CI [1.10, 3.49], $\chi^2(1) = 5.28$, $p = .022$), indicating that children from higher SES backgrounds were significantly more likely to have confidence in their vocabulary knowledge compared to their lower SES peers.

Table 4

Mediation analysis for vocabulary depth as measured by the attributes task

Effect	Estimate	95% CI	
		LL	UL
Indirect (ACME)	.22	.11	.36
Direct	.15	-.11	.41
Total	.37	.10	.64
Proportion of Total Effect Mediated	.59	.35	1.99

Note. The upper limit of the 95% confidence interval for the proportion mediated here exceeds 100%, a result that stems from the way this index is computed—as the ratio of the indirect effect to the total effect. When the total effect, used as the denominator, is small or unstable in bootstrap samples, the proportion mediated can surpass 100%. This instability limits the interpretability of the proportion of total effect mediated, making the indirect effect (ACME) a more reliable and interesting indicator (Hayes, 2009).

Table 5

Mediation analysis for vocabulary depth as measured by the synonyms task

Effect	Estimate	95% CI	
		LL	UL
Indirect (ACME)	.19	.09	.32
Direct	.48	.22	.73
Total	.67	.40	.91
Proportion of Total Effect Mediated	.28	.21	.47

6.5 Discussion

Our analysis revealed that SES predicts vocabulary breadth, in line with previous research (Hart & Risley, 2003; Hoff, 2003; Lervåg et al., 2019; Neuman et al., 2018). Critically, it also predicted performance on measures of depth, even after controlling for breadth in the synonyms task, which had not been previously investigated. This suggests that socioeconomic disparities extend beyond vocabulary size to include vocabulary depth. One likely explanation is that children from lower-SES are exposed to less rich and varied language (Hart & Risley, 1995; Hoff, 2006; Nag, 2023; Rowe, 2012). This restricted exposure not only limits the quantity of

words they are familiar with but also reduces opportunities to strengthen semantic relationships in their vocabulary over time.

According to the Lexical Legacy Hypothesis (K. Nation, 2017), frequent and diverse encounters with words in meaningful contexts help form robust lexical representations and strengthen their connections. The Lexical Quality Hypothesis (Perfetti & Hart, 2002) further suggests that strong lexical representations are crucial for effective reading and language processing which in turn enhance word knowledge, that is, the depth of vocabulary. Children from lower-SES backgrounds may therefore struggle to create stable, interconnected lexical representations, which is impacting vocabulary depth.

While the impact of SES on breadth is well documented (Buckingham et al., 2013; Hoff, 2003; Neuman et al., 2018), its impact on depth has not been studied. To our knowledge, this study provides one of the first empirical demonstrations that SES can affect vocabulary depth independently of vocabulary size. At the same time, the variability observed across depth measures highlights the complexity of the construct. Following prior frameworks, we assessed both intra-word knowledge and interlexical relationships (Meara & Wolter, 2009; Webb, 2012), and the results suggest that different tasks tap into different aspects of depth.

Specifically, SES effects persisted in tasks requiring interlexical processing, such as identifying semantic relations between words, even after controlling for breadth. In contrast, for the attributes task, SES effects disappeared once breadth was included in the model. This suggests that while a wider breadth of vocabulary can facilitate performance on measures relying on reading, SES continues to yield a direct influence on vocabulary depth when tasks require more interlexical processing, such as retrieving semantic links between words. The different patterns observed across tasks may therefore be explained by their specific demands and the capacities they solicit. In this study, the attributes task required reading and

understanding descriptions to determine whether they matched a word, whereas the synonyms tasks requested identifying related words.

The differential impact of SES on denomination and performance on the synonyms task suggests that breadth and depth remain distinct dimensions of vocabulary knowledge, consistent with studies demonstrating their independent contribution to reading (Ouellette, 2006; Tong & Tong, 2022). However, the finding that breadth mediated the SES effect on the attributes task reinforces the idea of carefully selecting measures of depth. Tasks that require producing or recognizing more words than a child actually knows may blur the distinction between these two domains of vocabulary. As Vermeer (2001) argues, they are inherently interrelated, making it difficult to isolate one without engaging the other. Hence, further research on additional facets of vocabulary depth in which SES may have a role might be beneficial.

The findings of this study make us consider the potential value of interventions that address both vocabulary breadth and depth, particularly for children from low-SES backgrounds. Although many vocabulary-building programs focus on expanding the number of words children know (Marulis & Neuman, 2010), our results suggest that supporting richer semantic representations and strengthening connections among words may also be important. For instance, strategies that encourage children to explore the meanings, usage, and semantic relationships of words in different contexts could be more effective in fostering deep, long-lasting vocabulary learning (Beck et al., 2013).

A couple of limitations of this study could be acknowledged. First, the measures of vocabulary depth were tailored for this study and, while they showed acceptable reliability, further validation is needed. Nonetheless, to our knowledge, this was the first attempt to measure breadth and depth separately to analyze the impact of SES. Second, in the present study we could not assess SES at the individual level. It was linked to schools rather than to each

child, which prevents us from disentangling the effects of children's own SES from potential effects of school-level characteristics. This limitation was relevant because school quality could partly account for the observed differences, as shown in previous work in English-speaking contexts demonstrating SES-related variability in instructional quality (Buckingham et al., 2013; Neuman et al., 2018). Even though all French schools follow the same national curriculum, we could not rule out unmeasured school-level influences. Finally, while we controlled for word recognition in our analyses, other cognitive or environmental variables, such as working memory (Rakesh et al., 2024) or home literacy practices (Neuman et al., 2018), could also influence the relationship between SES and vocabulary development.

Future research may benefit from using different tasks aiming to measure depth in order to identify where the line blurs with breadth. It would also be worthy to evaluate whether interventions that target vocabulary depth in addition to breadth can mitigate SES-related vocabulary gaps. Clarifying how both domains of vocabulary distinguish could inform more precise vocabulary research and educational practices.

6.6 Conclusion

In summary, this study highlights the impact of SES on the breadth and depth of children's vocabulary. Distinguishing between the breadth and depth of vocabulary may help design effective educational interventions to reduce the vocabulary gap between children from low- and high-SES backgrounds. In this regard, efforts to improve children's vocabulary must focus not only on the quantity of words they know but also on the quality and depth of their understanding.

Chapter 7: Word Learning Experimental Studies

7.1 Introduction to the Word Learning Studies

Two studies on word learning were carried out in schools. In these studies, children learned rare, novel words. Study 2 manipulated exposure modality to compare the impact of oral versus written exposure. Study 3 compared written exposure to sequential oral and written exposure. These studies aimed to examine the role of learning modality in word learning. Specifically, we wanted to determine if the pattern of lexical development from configuration to lexicalization differs based on how the novel word is encountered.

As we saw in Chapter 3, the process by which a word transitions from unknown to known involves two processes. One is lexical configuration, defined as the mental representation of a word's properties (e.g., orthography, phonology, and meaning) following initial exposure. The other is lexicalization, which describes how newly learned words interact with existing ones as they are integrated into the mental lexicon. This framework is based on the description by Leach and Samuel (2007).

Additionally, we have already discussed that words must also integrate semantic, phonological, and orthographic representations, all of which must be well-interconnected to be of high quality. Therefore, to more accurately evaluate the lexical development process, it is necessary to assess the configuration and lexicalization of all three representations. However, most word learning studies, regardless of learning modality, have focused on one of these processes, and overall, on the lexicalization of word's form aspects (phonology and orthography) in adults. In the following two studies, we taught schoolchildren unfamiliar words and then assessed the resulting lexical development from lexical configuration and lexicalization using tasks that tapped into orthographic, phonological, and semantic representations.

Below, a description of the commonalities between the two experiments. Then, each experiment will be described in detail, including their specific methodologies, results, and discussions.

7.1.1 Learning Material

The learning material in both of the studies was the same. It consisted of 16 very rare words (M frequency: 0,45 per million; M length: 6,6 letters), drawn from four semantic categories: animals, clothing, fruits, and musical instruments. Each word was paired with four descriptive sentences constructed based on dictionary definitions (Appendix 4). Novelty was confirmed through pilot testing with age-matched children from higher-SES backgrounds and teacher reports indicating that none of the words had been previously taught.

As we saw before, the use of semantic information may help to the lexicalization of words (Leach & Samuel, 2007). This has been supported by subsequent research in childen both orally and through written support (Henderson, Weighall, & Gaskell, 2013; Tamura et al., 2017). Henderson and colleagues (2013), found that when children were exposed to meaning during oral training on real science words, compared to no meaning exposure, exhibited stronger lexicalization as measured by a pause detection task. Similarly, Tamura et al., (2017) found that incidental exposure to orthographic forms of novel words embedded in stories led to both configuration and lexicalization. This suggests that children can exhibit lexical effects after learning in both modalities but it is not clear to what extent one modality would be more efficient than the other to fuel the word learning process.

7.1.2 Experimental tasks

The experimental protocol comprised a set of tasks aiming to evaluate configuration and lexicalization of the newly learned words, tapping onto orthographic, oral and semantic representations. These were administered either on a computer or in booklet format. Booklet-based tasks were completed individually by all children simultaneously in their classroom,

whereas computer-based tasks were administered in small groups of up to five children in a quiet separate room.

1. **Spoken Word Recognition Task:** In this task, administered on computer, children listened to a random list of real words (32) and pseudowords (32). The real words included 16 known words (M frequency = 54.2; SD=51.39) and the 16 learned words (see Appendix 5). The task used a Go/No-Go paradigm, thus children wore headphones and were requested to press the space bar only when they heard a real word.
2. **Written Lexical Decision Task:** In this task, administered on computer, children were shown a series of letter strings on a screen for up to 2000 milliseconds. Half of the stimuli (32) were real words (M frequency = 19.34; SD = 3.32) and included the 16 learned words, the other half (32) were pseudowords (see Appendix 6). Children were requested to press, as fast as they could, the "J" key when the string in the screen was a real word and the "F" key when the string was a pseudoword.
3. **Orthographic Judgment Task:** For this task, administered on the booklet, each learned word was matched with three distractors: an orthographic close distractor (with one letter transposed) (e.g., *clavecin*/*calvecin*), a homophone distractor (with similar pronounciation) (e.g., *clavecin*/*clavessin*) and an orthographic distant distractor (with different letters at the end and different pronounciation) (e.g., *clavecin*/*clacefan*). All the stimuli were matched for number of letters (Appendix 7). Thus, children saw the four stimuli on the page of the booklet and were requested to indicate the correct spelling by circling their choice.
4. **Semantic Masked Priming Task:** This task was administered on computer and followed the masked priming paradigm described by Tamminen and Gaskell (2013). For each learned word, three semantically related and three semantically unrelated

matches were selected (M frequency = 22.50; SD = 18.09). Importantly, none of the related targets appeared during the learning phase. For example, the novel word *clavecin* [harpsicord] was associated with *guitar*, *drum*, and *trombone* for the semantically related condition and with *singer*, *waiter* and *writer* for the semantically unrelated condition. On each trial, children were presented with real words and pseudowords and were instructed to respond as quickly and accurately as possible by pressing "J" for real words and "F" for pseudowords. Real-word targets were always preceded by learned-word primes, whereas pseudowords were preceded by pseudoword primes (see Appendix 8). The primes happened during 51ms, meaning it was subliminal.

5. **Sentence Judgment Task:** This task was administered in booklet format. For each learned word, two sentences were created, one semantically congruent and one incongruent (see Appendix 9). At each testing point, children read 16 sentences, half congruent and half incongruent. All sentences were grammatically and syntactically correct and differed only in semantic plausibility. Children indicated whether each sentence made sense by circling "yes" or "no" in the booklet.

For the sentence judgment task, performance in Study 2 showed little variation across sessions in either study. Upon examination, it looked like the instructions might have caused children to evaluate the sentences based on grammatical acceptability rather than semantic plausibility. Since all the sentences were grammatically correct, the children may have judged them as acceptable regardless of whether the semantic content was congruent with the target word (e.g., "I eat a hapsichord" vs. "I take hapsichord classes"). Consequently, the version of the task used here may not have provided a sensitive measure of semantic representations of the newly learned words. The analyses for this task are thus not included in the manuscript. However, they are described in Appendix 10 to provide a complete overview.

7.1.3 Background measures

In both studies, children also performed a group of control tasks, that were administered to assess children's reading-related skills and nonverbal cognitive abilities. Rapid word recognition was assessed using the same task used in Study 1 (see Appendix 3). Decoding and reading fluency were evaluated using the subtests from the written and oral language assessment battery (EVALEO; Launay et al., 2018). Nonverbal intelligence was measured using Raven's standard progressive matrices (John & Raven, 2003). Each task is described below.

Rapid word recognition: This task appeared at the end of the booklet containing the booklet-based experimental tasks. Once children had concluded these tasks, the teacher and experimenters ensured that they did not turn the page to see the words in the four columns. Once all the children were ready, the experimenter explained that they had one minute to cross out only the pseudowords and started the timer.

Decoding: Children were asked to read aloud a list of 22 pseudowords presented in print. Pseudowords were phonotactically legal in French and increased in complexity. The dependent measure was the number of items read correctly.

Reading Fluency: Children were instructed to read aloud a continuous text with low semantic predictability for 1 minute (the original task duration is 3 min). The dependent measure was the number of words read correctly within the 1-minute time limit.

Non-Verbal Intelligence: In this task, children are presented with a series of incomplete visual matrices of increasing difficulty and are asked to select the missing element from a set of alternatives. Half of the test items (even items) were administered. The score was the total number of correctly completed matrices.

7.1.4 Ethics

In both of the studies, informed consent was obtained from the children's legal guardians. The same model of simplified letter was used to ensure comprehension (see Appendix 1). In

every session of both of the experiments, oral assent was secured from the children before the protocol started. Children were informed of the option to withdraw at any time. Teachers confirmed that participants had no learning, cognitive, sensory (e.g., uncorrected visual or hearing impairments), or psychiatric disorders, based on their access to student records and regular interactions. Both of the studies were approved by the Ethical Committee from Lille University and complied with the EU General Data Protection Regulation (GDPR) under the supervision of the Data Protection Official at the same university. Both of the studies adhere to the ethical principles outlined in the Declaration of Helsinki.

7.2 Study 2 – Comparing Oral and Written Modality

This study revisits the content of an article published in the *Journal of Experimental Child Psychology*. The original title of the article is "**Learning Words by Ear or by Eye: Effects of Modality on Lexical Configuration and Lexicalization**" (Vargas-Cuevas, Javourey-Drevet, et al., 2026).

7.2.1 Introduction

Once children learn to read, they shift from acquiring new words primarily through oral input to learning through written input via orthography (Cunningham, 2005; Share, 2008b). Therefore, children's vocabulary continues to grow as they encounter new words throughout school and later in life, both orally, through conversations or by hearing others speak, and in print, through academic contexts or general reading (Nagy et al., 1985). Previous studies have suggested that modality plays a role in word learning (Bakker et al., 2014; Melamed et al., 2024; J. Nelson et al., 2005; Valentini et al., 2018). Thus, in this study, we investigated the extent to which these two modalities (oral and visual, through orthography) impact the acquisition of novel words in children who have learned to read.

As discussed in Chapter 3, the word learning process involves the configuration of a novel word representation and typically results in its lexicalization (Leach & Samuel, 2007). Tasks that assess lexical configuration typically involve the recall or recognition of new words because these tasks can be performed using form-related traces. In contrast, lexicalization is evidenced when new words begin to exhibit interaction at all levels (phonemic, lexical, and semantic) within the lexical systems, such as competition or facilitation, including semantic priming, for example.

Likewise, we have argued that word learning involves forming connections between phonological, orthographic, and semantic representations. Therefore, when evaluating the lexicalization of words, it would be appropriate to evaluate all these three components.

Nonetheless, much of the research on the integration of novel word representation has focused on spoken language with extensive research in adults (Blomquist & McMurray, 2023; Clay et al., 2007; Davis & Gaskell, 2009; Dumay & Gaskell, 2007; Gaskell & Dumay, 2003; Leach & Samuel, 2007; Tamminen & Gaskell, 2013) and a smaller literature in children (Henderson et al., 2012; Henderson, Weighall, & Gaskell, 2013; James et al., 2019).

Another body of literature has explored the acquisition of novel words presented in spoken or written modalities. Suggate et al. (2013) showed that eight- to ten-year-olds more readily acquired the meaning of novel words when they were inserted into stories. Valentini et al. (2018) demonstrated that eight- and nine-year-old children who read a story containing novel words could infer the phonological forms of those words, whereas those who only listened could not infer the orthographic representations. More recently, Melamed et al. (2024) found that written input enhanced meaning inference more than spoken input across development (8 to 15 years old). Importantly, all of these studies assessed learning using only recognition tasks; that is, they measured configuration only.

If initial exposure shapes the lexical configuration of a word, it may also influence its eventual lexicalization. For instance, novel spoken words may prompt the creation of anticipated orthographic forms (Grainger et al., 2005; Johnston et al., 2004), whereas written input can reinforce phonological mappings and facilitate access to meaning through visual cues (Coltheart et al., 2001). Thus, the question arises as to whether lexical quality and lexicalization depend on the modality through which a word is first encountered.

Two theoretical accounts illustrate how modality-specific information may contribute to lexical development. In Chapter 4, we presented the Orthographic Facilitation Hypothesis, in which the presentation of simultaneous phonological (P) and orthographic (O) inputs facilitates the acquisition of new words. In these experiments, researchers typically compare the P+O condition with the P-only condition. Based on the LQH (Perfetti & Hart, 2002) , it is reasonable

to conclude that presenting two types of information is more effective than presenting only one. However, one question remains: To what extent can each modality be beneficial on its own?

Thanks to the Orthographic Facilitation Hypothesis, we know that the simultaneous presentation of orthography and phonology are helpful in learning the form of a word (orthography and phonology), with some evidence for semantic learning (Colenbrander et al., 2019). We also mentioned the Orthographic Skeletons Hypothesis, which proposes that exposure to spoken forms of words generates orthographic representations.

Most tasks used to measure learning in these paradigms, however, rely on recognition tasks that assess rather associative knowledge between a word form and semantic information. Examples include forced-choice tasks for phonology and orthography, as well as spelling to dictation and word-meaning matching (e.g., picture-word matching and verbal definitions), with a few examples of semantic categorization. Furthermore, these kinds of measures are usually taken immediately after learning (but see Ricketts et al., 2021 for a longitudinal example). Understanding the lexical development process requires measuring the entire process, from configuration to lexicalization. This requires measures not only of recognition and matching but also of both learning phases.

The present study was intended to address this gap. In the present study, we combined immediate recognition measures with tasks evaluating lexical effects over time to examine how modality influences both configuration and lexicalization of novel words. We therefore trained children in a natural learning context (school), via oral or written support, without drawing attention to any specific representation of words (i.e., orthography, phonology or semantics).

7.2.2 Research questions and hypotheses

The aim of this study was to investigate whether the modality of word learning (oral or written) influences the configuration and lexicalization of newly learned words differently in

children from low socioeconomic backgrounds. Specifically, we asked which modality leads to more effective word learning.

Based on previous literature, specifically the "mnemonic value of spelling for word learning" proposed by Rosenthal and Ehri (2008), and the results reported by Melamed et al. (2024) and Valentini et al. (2018), we predicted that visual training with orthography would promote more efficient lexical configuration. Regarding the lexicalization stage, we expected facilitated recognition after integration in both modalities, consistent with previous studies (Bakker et al., 2014; Tamura et al., 2017), as well as semantic priming effects (Tamminen & Gaskell, 2013). However, regarding the impact of modality at this stage, we had no reason to expect a different pattern than that observed at the lexical configuration stage. Prior to this experiment, there was a lack of empirical data on this issue.

7.2.3 Method

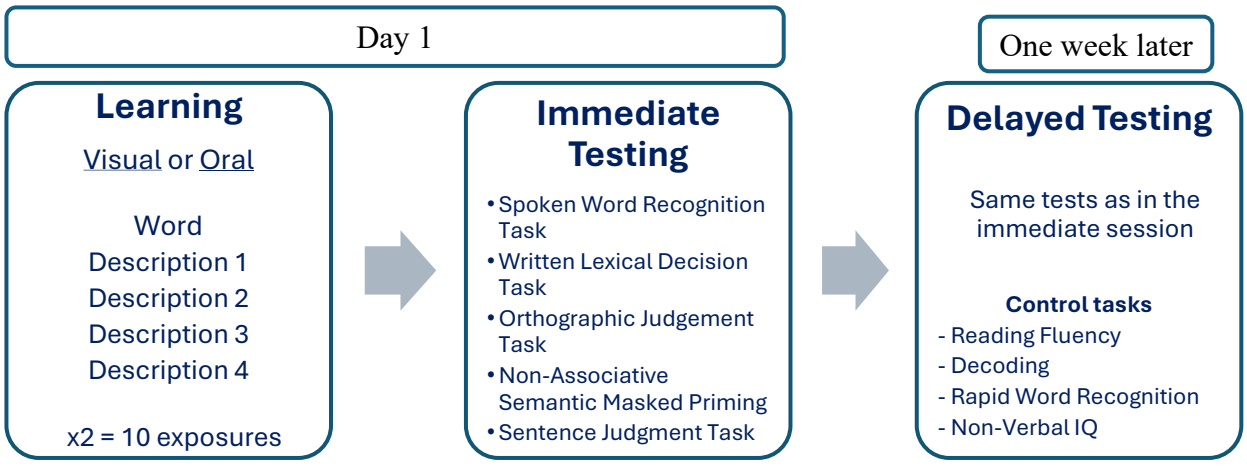
7.2.3.1 Participants

Participants were 107 fourth- and fifth-grade students. Due to missing data, analyses were conducted for 95 participants (M Age = 9,72; SD = 1,26) from five classes in two low-SES schools in France. All participants spoke French as their primary language. School SES was indexed using the IPS (Dauphant et al., 2023). The participating schools had IPS scores well below the national mean (M= 104; present study population’s IPS M= 69), ensuring that participating children were drawn from similar low-SES environments.

7.2.3.2 Procedure

Each class was randomly assigned to one learning modality. Three classes learned the words through oral exposure (n=60), and two classes through visual exposure (n=35). In the oral condition, children listened to their teachers pronouncing each word followed by the four descriptions that were read aloud. Once they have heard the 16 words with their descriptions, teachers repeated the process once. Thus, children heard each word a total of 10 times. In the

Figure 1
Description of Protocol in Study 2



visual condition, children received a booklet containing all the words with their descriptions. Each page contained one word followed by the four descriptions one by one. Once children had finished reading all the words and their descriptions, they were instructed to start again. Ensuring that each word was also encountered 10 times. In both conditions children were aware that they were going to be tested on the words that they were to learn, but no attention was drawn to any particular linguistic aspect of them.

The experiment consisted of two sessions, summarized in **Figure 1**. During the first session, children completed the learning phase followed by the immediate testing (to assess lexical configuration) comprising the experimental tasks. The booklet-based tasks were always administered before the computer-based tasks. The second session took place one week later, and included the experimental and the control tasks. Table 6 presents descriptive statistics for the results obtained on the latter by both learning groups.

7.2.4 Preregistration and Data availability

This study was preregistered and can be found at : https://aspredicted.org/4cmj-5kwj.pdf The data supporting the findings of this study are available on a public repository at: https://doi.org/10.57745/I2MXIL.

Table 6

Descriptive statistics for the control tasks by learning condition.

Task	Condition	Mean	SD
Decoding	Oral	17.63	3.11
	Visual	18.77	2.70
Fluency	Oral	98.80	19.14
	Visual	105.49	23.62
Rapid Word Recognition	Oral	33.43	15.83
	Visual	28.66	10.76
Raven	Oral	14.40	3.70
	Visual	13.49	4.33

Note. For the decoding task, the maximum possible score was 22. For reading fluency and rapid word recognition, there was no maximum score, as performance was time-limited to 1 min. For Raven's Progressive Matrices, values correspond to the mean number of correctly solved matrices.

7.2.5 Results

Table 7 presents children's performances on the experimental tasks involving the learned words; all the main analyses were conducted on these data. Accuracy and reaction times (RTs) were analyzed for the computer-based tasks, whereas accuracy was analyzed for the booklet-based tasks. In order to ensure task compliance, participants with an accuracy rate below 60% on the known words in the written lexical decision and in the semantic priming in general, were excluded from the analyses. For the Spoken Word Recognition task, which used a Go/No-Go procedure, participants with a hit rate below 55% or a false alarm rate above 60% were excluded. RT analyses were conducted only on correct responses. Trials with RTs shorter than 200ms or exceeding ±2 SDs from each participant's mean were excluded to avoid the influence of extreme outliers (2008). Across tasks, these exclusions never surpassed 5% of trials. Accuracy data was analyzed using logistic mixed-effects models (Jaeger, 2008) and RTs were analyzed using generalized mixed models with gamma distribution and identity link functions. Such modeling approach is well suited for positively skewed RT distributions and permits the analysis of raw RT values while accounting for both within- and between-participant variability (Baayen et al., 2008). Given the complexity of mixed-effects modeling and the constraints of school-based data collection, statistical sensitivity was addressed by ensuring a large number

of observations. Accordingly, the number of observations per task was substantial –ranging from at least 8,226 to 32,062 in the spoken word recognition and semantic priming tasks, respectively– which helps mitigate concerns related to statistical power (Brysbaert & Stevens, 2018).

Fixed effects systematically included learning modality (oral vs. visual), session (immediate vs. delayed), and their interaction. Random intercepts were specified for participants and targets, with random slopes of session by-participant. Additional random slopes were included when model comparison indicated a significant improvement in model fit (Barr et al., 2013); their inclusion is reported in the text when appropriate. Confidence intervals were obtained by calculating 1000 bootstrap samples.

Group differences on control tasks were assessed using Welch's ANOVA and were non-significant at $p < .05$. Therefore, they were not included as predictors in the mixed models, to avoid innecessary model complexity. All analyses were implemented in Jamovi 2.6 (The jamovi project, 2024) and the mixed effects analyses were conducted using the GAMLj package (Version 3.6; Gallucci, 2019).

Table 7

Descriptive statistics for the experimental tasks by learning modality and session.

Task	Learning Modality	Session	Accuracy		Reaction Time (ms)		Relationship
			Mean	SD	Mean	SD	
Spoken Word Recognition	Oral	Immediate	0.59	0.49	1233	274	—
		Delayed	0.70	0.46	1247	273	—
	Visual	Immediate	0.56	0.50	1269	320	—
		Delayed	0.71	0.46	1293	282	—
Written Lexical Decision	Oral	Immediate	0.62	0.49	1024	332	—
		Delayed	0.67	0.47	977	333	—
	Visual	Immediate	0.72	0.45	971	293	—
		Delayed	0.83	0.38	895	279	—
Orthographic Judgment	Oral	Immediate	0.51	0.50	—	—	—
		Delayed	0.62	0.49	—	—	—
	Visual	Immediate	0.75	0.44	—	—	—
		Delayed	0.81	0.40	—	—	—

Semantic Masked Priming	Oral	Immediate	0.82	0.38	951	313	R
					952	310	NR
		Delayed	0.80	0.40	918	291	R
					935	308	NR
	Visual	Immediate	0.82	0.39	927	295	R
					933	313	NR
		Delayed	0.84	0.37	881	269	R
					886	269	NR

Note. RTs are in milliseconds; R = Semantically related priming; NR = Non-semantically related priming; SD = Standard deviation.

Analysis of phonological processing

Table 8 presents the results for the statistical models applied to the spoken word recognition task.

Table 8

Model for Accuracy in the Spoken Word Recognition Task

Fixed Coefficients				**Random Effects**			
Parameters	**Estimate**	**SE**	**z**	**Groups**	**Name**	**Variance**	**SD**
Spoken Word Recognition							
1	0.79	0.19	4.22	**Participant**	(Intercept)	1.57	1.25
2	0.06	0.31	0.18		Session	0.21	0.46
3	0.71	0.15	4.75	**Target**	(Intercept)	0.17	0.42
4	-0.16	0.29	-0.55	**Residual**		3.29	1.81

Note. Parameters correspond to: (1) Intercept; (2) Learning modality (Visual – Oral); (3) Session (Delayed – Immediate); (4) Learning Modality × Session interaction.

7.2.5.1.1 Spoken Word Recognition - Accuracy

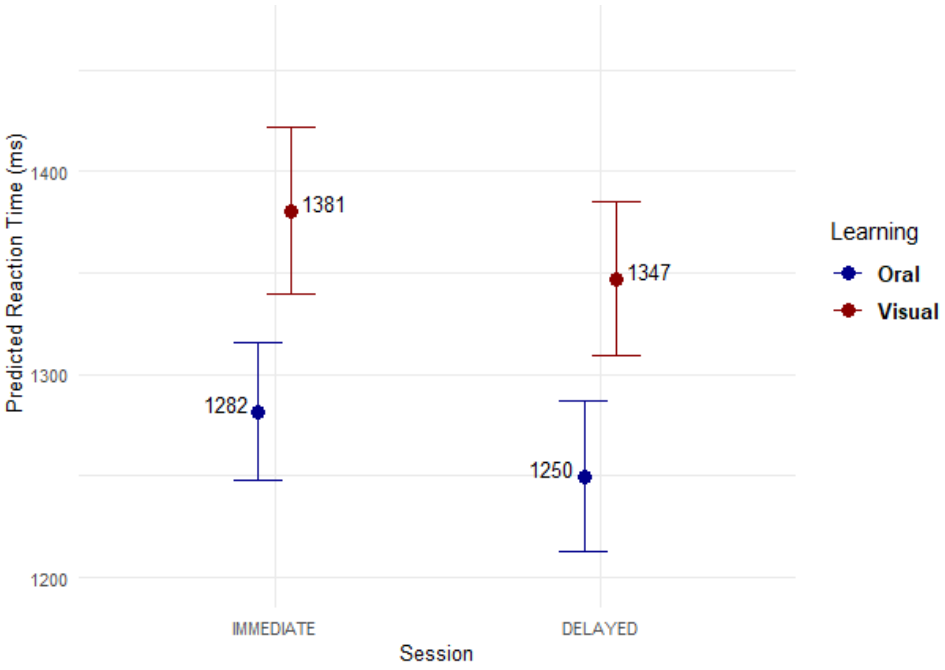
For the spoken word recognition task, the main model revealed a significant effect of session, χ^2 (1) = 22.57, $p < .001$, indicating higher accuracy in the delayed session for both groups (OR = 2.03, 95% CI [1.51, 2.71]). The effect of learning modality was not significant ($p = .854$). No significant interactions were found between learning modality and session either ($p = .564$).

7.2.5.1.2 Spoken Word Recognition - RT

The best fitted model to analyze the RTs for the spoken word recognition task dropped the random slope of session by-participant. There was a significant effect of learning modality, indicating slower responses for the visual group, χ^2 (1) = 49.88, $p < .001$. A significant effect of

session was also observed with overall faster responses in the delayed session, χ^2 (1) = 12.63, p < .001. No significant interactions were found, χ^2 (1) = 0.01, p = .940. **Figure 2** presents the estimated marginal means (EMMs) obtained from the model.

Figure 2
Estimated Marginal RTs in the Spoken Word Recognition Task by Learning Modality and Session. Error bars indicate 95% confidence intervals.



7.2.5.2 Analysis of orthographic processing

Table 9 presents the results for the statistical models applied to the orthographic judgment and the written lexical decision tasks.

Table 9

Models for accuracy in the orthographic tasks

Fixed Coefficients				Random Effects			
Parameters	**Estimate**	**SE**	**z**	**Groups**	**Name**	**Variance**	**SD**
Written Lexical Decision							
1	1.27	0.21	5.99	**Participant**	(Intercept)	1.55	1.25
2	0.87	0.29	2.98		Session	0.56	0.75
3	0.72	0.16	4.46	**Target**	(Intercept)	0.36	0.60
4	0.38	0.31	1.23	**Residual**		3.29	1.81

				Orthographic Judgment			
1	0.96	0.17	5.56	**Participant**	(Intercept)	0.56	0.75
2	1.24	0.24	5.23		Session	0.25	0.50
					(Intercept)	0.33	0.57
3	0.57	0.18	3.14	**Target**	Learning	0.31	0.56
					Session	0.30	0.54
4	-0.01	0.23	-0.05	**Residual**		3.29	1.81

Note. Parameters correspond to: (1) Intercept; (2) Learning modality (Visual – Oral); (3) Session (Delayed – Immediate); (4) Learning Modality × Session interaction.

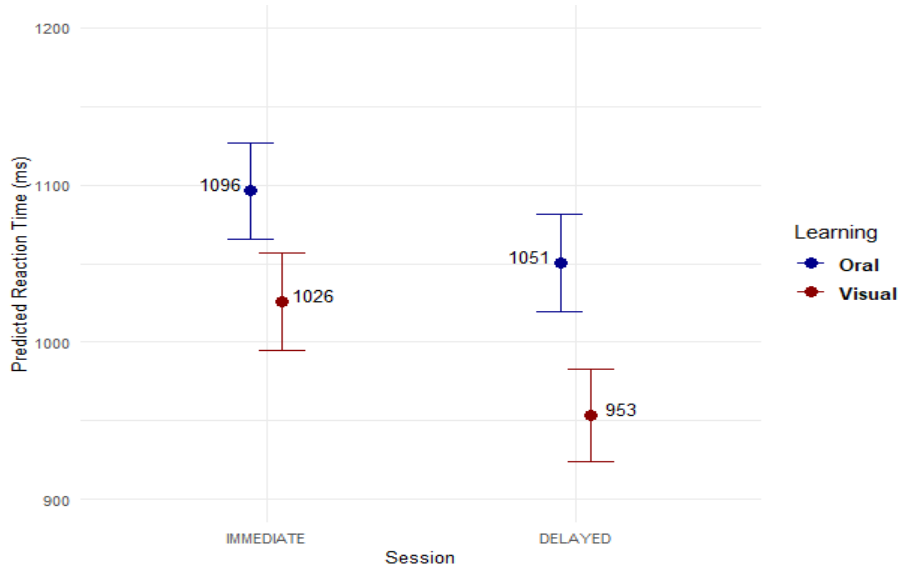
7.2.5.2.1 Written Lexical Decision – Accuracy

The main model for the written lexical decision task revealed a significant effect of learning modality, χ^2 (1) = 8.91, p = .003, indicating that participants in the visual condition were more accurate overall (OR = 2.39, 95% CI [1.35, 4.24]). There was also a significant effect of session, χ^2 (1) = 19.92, p < .001, with higher overall accuracy observed in the delayed session (OR = 2.06, 95% CI [1.50, 2.84]). The interaction between learning modality and session was not statistically significant, χ^2 (1) = 1.51, p = .220.

7.2.5.2.2 Written Lexical Decision – RT

The main model for the written lexical decision yielded a significant effect of learning, with participants in the visual learning condition showing faster responses overall, χ^2 (1) =

Figure 3
Estimated Marginal RTs in the Written Lexical Decision Task by Learning Modality and Session. Error bars indicate 95% confidence interval.



69.63, $p < .001$. There was also a significant effect of session, with faster responses in the delayed session χ^2 (1) = 3.62, $p = .057$. No significant interaction was observed, χ^2 (1) = 2.00, $p = .157$. **Figure 3** illustrates the estimated marginal means obtained from the model.

7.2.5.2.3 Orthographic Judgment

The model for the orthographic judgment task included the random slopes of session and learning by-target. It showed a significant effect of learning modality, χ^2 (1) = 27.36, $p < .001$, with participants in the visual condition demonstrating higher accuracy overall (OR = 3.45, 95% CI [2.17, 5.48]). A significant effect of session was also observed, χ^2 (1) = 9.88, $p = .002$, with better performance in the delayed session for both groups (OR = 1.76, 95% CI [1.24, 2.51]). No significant interaction between learning and session were found, $p = .906$.

7.2.5.3 Analysis of semantic processing

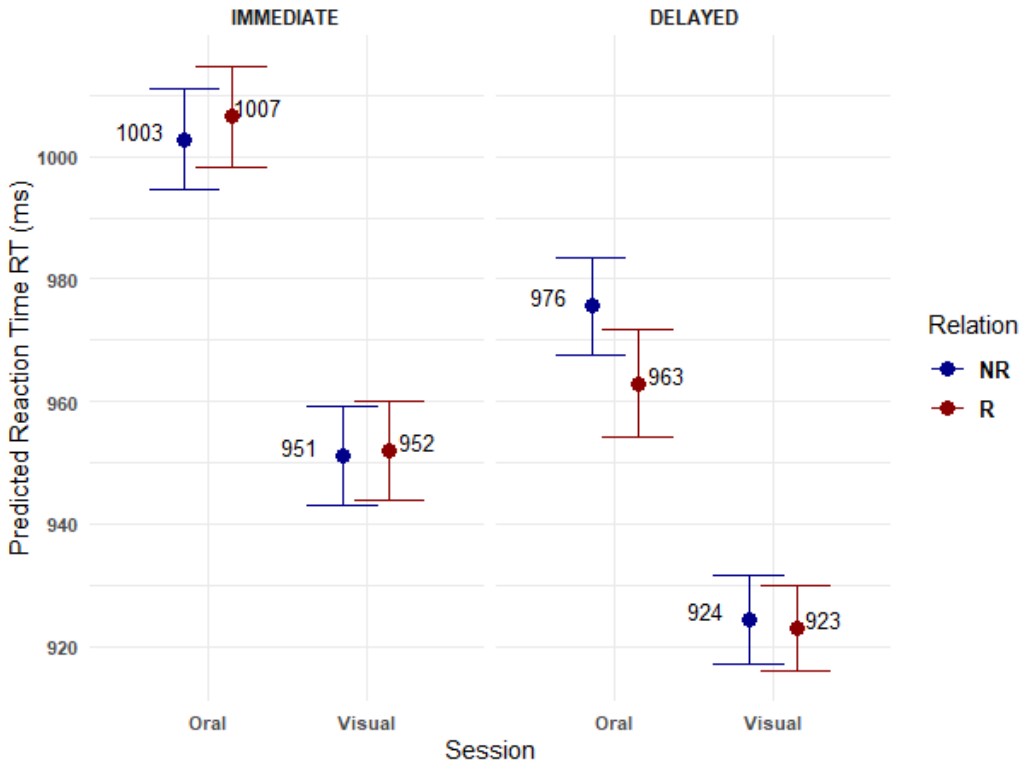
7.2.5.3.1 Semantic Masked Priming

The model to analyze RTs in the semantic priming task included the fixed effect of relation and random slopes of relation by prime. It revealed significant effects of learning modality, χ^2 (1) = 300.95, $p < .001$, and session, χ^2 (1) = 160.65, $p < .001$. The effect of relation was not significant, χ^2 (1) = 0.54, $p = .464$. Significant two-way interactions were observed for learning by session, χ^2 (1) = 4.81, $p < .028$, and session by relation, χ^2 (1) = 6.29, $p < .012$. Crucially, a significant three-way interaction emerged for learning by session by relation, χ^2 (1) = 25.70, $p < .001$. **Figure 4** shows the EMMs of the model.

To further examine this three-way interaction, separate analyses were conducted by learning condition. In the visual-learning condition, an effect of session was found, χ^2 (1) = 30.06, $p < .001$, with faster responses in the delayed session (β = - 40.25 ms). Neither the main effect of relation, χ^2 (1) = 2.33, $p = .127$, nor the interaction between relation and session was significant, χ^2 (1) = 0.74, $p = .388$. On the other hand, the oral-learning condition revealed effects of session, χ^2 (1) = 28.55, $p < .001$, and relation, χ^2 (1) = 6.89, $p = .009$, as well as their

Figure 4

Estimated Marginal RTs in the Masked Semantic Priming Task by Learning Modality, Session, and Semantic Relation.



NR= Non-Semantically Related Condition. R= Semantically Related Condition. Error bars indicate 95% confidence intervals.

interaction , χ^2 (1) = 7.57, p = .006. Post hoc comparisons with Bonferroni correction indicated that a priming effect emerged in the delayed session. That is, while in the immediate session there was not a significant difference in RTs between related and unrelated targets, participants in the oral group responded significantly faster to related targets than to unrelated ones in the delayed session (β = -13ms, $p_{bonferroni}$ = .001). For comparison, although participants in the visual-learning group also responded numerically faster to related than to unrelated targets in the delayed session, this difference did not reach statistical significance.

7.2.5.4 Further analyses

Another way to examine lexical integration is assessing changes in accuracy for learned words relative to known words as these latter serve as a baseline to compare performance across

time. Therefore, we conducted such analyses separately for each task. Logistic Mixed effects models were fitted with session (immediate vs delayed) and word type (learned vs known) as fixed effects, and participants and targets as random effects, including a random slope of session by participant. The models revealed significant interactions of session and word type at $p >$ .001, indicating that accuracy for learned words improved over time. Children's accuracy started well below that of known words but reached comparable levels after one week in the written lexical decision (OR = 0.43, 95% CI [0.32, 0.56]) and the spoken word recognition tasks (OR = 0.43, 95% CI [0.32, 0.56]). Estimated marginal means for these models are reported in Table 10.

Table 10

Estimated marginal means for accuracy as a function of session and word type in each task.

Session	Word type	Spoken Word Recognition				Written Lexical Decision			
		Mean	SE	95% CI		Mean	SE	95% CI	
				Lower	Upper			Lower	Upper
Immediate	**Known**	0.72	0.05	0.61	0.80	0.82	0.03	0.75	0.87
	Learned	0.60	0.06	0.49	0.70	0.69	0.05	0.59	0.77
Delayed	**Known**	0.71	0.05	0.61	0.79	0.76	0.04	0.67	0.84
	Learned	0.73	0.04	0.64	0.81	0.79	0.04	0.70	0.85

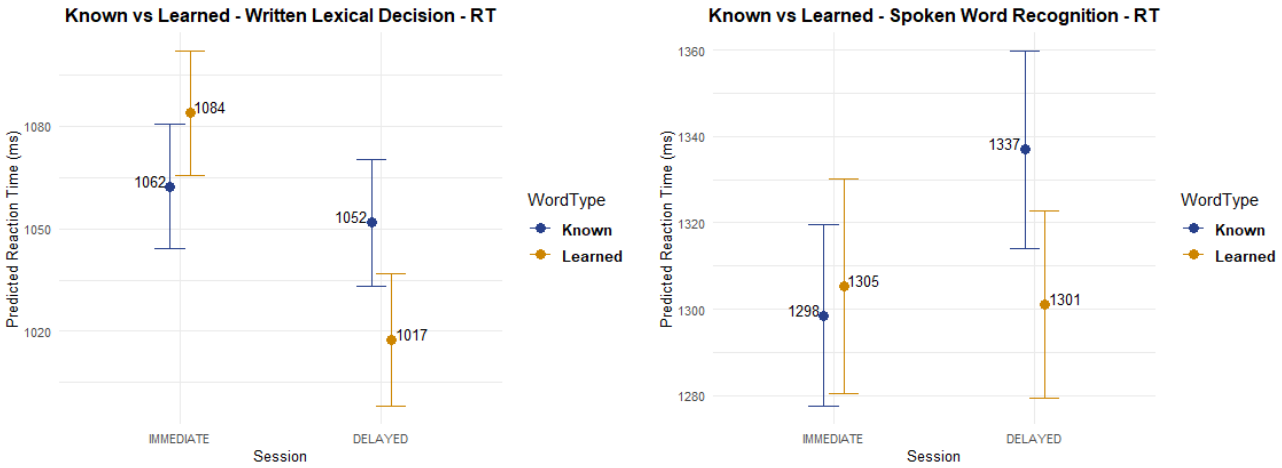
Note. Accuracy values are estimated marginal means (EMMs) with standard errors (SEs) and 95% confidence intervals (CIs).

Generalized mixed effects models were also conducted to assess changes in RTs for learned words over time, compared to known words. Each model included session (immediate vs delayed) and word type (learned vs known) as fixed effects, with participants and targets as random effects, and a random slope of session by participant. The analyses revealed a significant interaction between session and word type ($p >$ .001) in both tasks also. In the written task, RTs for learned words became significantly faster over time (β = -66.42ms, $p_{bonferroni} <$ .001) with no significant change to the known words. In the oral task, children surprisingly showed a significant increase in their RT to known words (β = 38.51ms, $p_{bonferroni} <$ .001) with no significant change for the learned ones, indicating that the changes for these words are driven

by learning modality. The change in pattern for the known words is addressed in the discussion.

Figure 5 illustrates the EMMs for these models.

Figure 5
Estimated Marginal RTs for Known and Learned Words in the Written Lexical Decision Task and The Spoken Word Recognition Tasks by Word Type and Session. Error bars indicate 95% confidence intervals.



7.2.6 Discussion

This study investigated the impact of oral versus written learning modalities on word learning in school-aged children from low-income backgrounds, using measures of lexical configuration and lexicalization. Specifically, we examined which modality promotes more effective lexical development. Fourth and fifth graders were trained on rare novel words embedded in sentences providing context, which were presented either orally, through speech, or visually, through written support. Lexical development was assessed immediately after learning, to measure lexical configuration indexed by recognition tasks, and one week later, to measure lexicalization indexed by lexical decision tasks (i.e, involving RTs) and semantic priming. In this way, we could trace how orthographic, phonological, and semantic representations established across time under each modality.

In terms of configuration, the results from the immediate session for the spoken word recognition, written lexical decision and orthographic judgment tasks provide valuable

information about novel word recognition. For this reason, these tasks are first discussed in relation to the role of modality in lexical configuration. Since the progression of performance in the delayed session and the appearance of semantic priming provide better insight into the lexicalization process these aspects are examined right after.

7.2.6.1 Modality and Lexical Configuration

In the task assessing the emergence of phonological representations, the spoken word recognition task, no effect of modality was observed on accuracy. In the immediate session, both groups were roughly above chance to indicate whether the learned words were real words or not. An improvement in accuracy was observed over time for both groups, but this will be further developed in the lexicalization section. Concerning RTs in the same task, the group that learned with orthography was significantly slower overall, exhibiting a consistent delay from the immediate session.

Given that both groups had similar accuracy but differed in RTs from the immediate session in this task, it might be the case that orthographic information is being used more readily to configurate the novel words' phonological representations, and that such orthographic information is being recalled during oral recognition interfering in the time necessary to provide an answer.

In comparison, the orthographic tasks revealed, as expected, higher overall accuracy and faster RTs for children who learned in the visual condition (i.e., with print). In the written lexical decision task, the visual group exhibited higher accuracy and faster RTs than the oral group from the immediate session. This means that written input appeared to be more beneficial than oral input for children to recognize the orthographic forms of novel words more quickly and more accurately.

Turning to the orthographic judgment, it is important to note that in this task there were close distractors, with one letter transposed, (e.g., *clavecin*/*calvecin*), homophone distractors,

with similar pronunciation (e.g., *clavecin*/*clavessin*), and orthographic distant distractors, with different letters at the end and different pronounciation (e.g., *clavecin*/*clacefan*). This design enabled the evaluation of more fine grained knowledge of the word form than the two previous tasks. In those tasks, the contrast between the targets and the distractors was more evident.

In the orthographic judgment task, children who learned visually exhibited higher accuracy overall, with a consistently significant difference compared to the oral group. While the oral group performed around chance in the immediate session, the visual group was way above that level of accuracy. This indicates that children exposed to orthography developed more precise word-form representations than those exposed only to phonology. Notably, this advantage emerged immediately after learning.

Thus, it seems that orthography was more readily used for the configuration of phonological and orthographic representations. Although children who learned with it were slower to respond, but there was no significant difference in accuracy for recognizing novel word forms presented orally. In other words, print provided as much phonological information as oral input for orally recognizing newly learned words and led to better performance in recognizing the orthographic forms of novel words.

These results are consistent with the Orthographic Facilitation hypothesis (Ricketts et al., 2009; Rosenthal & Ehri, 2008) that suggests that orthographic information strengthens word learning. Extending previous work in which orthography, phonology, and semantics are typically presented simultaneously, the present findings demonstrate that exposure to print alone supports robust lexical configuration. More importantly, orthographic exposure enabled greater sensitivity to fine-grained orthographic distinctions. This is in line with the results from Valentini et al. (2018) and Melamed et al. (2024), who observed that children acquired phonological representations through exposition to print and benefitted more from orthography to recognize words. More broadly, the results support Ehri's (1992) proposal that orthography

serves as a powerful mnemonic cue in word learning, facilitating the formation of detailed and durable lexical representations.

7.2.6.2 Modality and Lexicalization

If words were lexicalized, they were expected to show both facilitated recognition, meaning faster RT and improved accuracy over time as well as semantic priming effects. Consistent with this prediction, faster RTs across sessions were observed across all tasks, meaning that both learning groups improved their performance in modality-congruent and cross-modal tasks with no systematic advantage for a specific modality. In other words, regardless of modality, novel words were equally lexicalized with respect to word form representations (phonological and orthographic) after one week. This is in line with studies showing that new words take some time before getting integrated into the lexicon (Dumay & Gaskell, 2007; Henderson et al., 2012).

At this point, it is important to consider the results comparing learned and known words, as they provide further insight into the lexicalization process. Across tasks, accuracy for learned words increased over time, reaching levels comparable to those of known words after one week. This convergence reinforces the idea that novel words were lexicalized, as they behave like familiar words in terms of recognition easiness.

Regarding RTs, in the written lexical decision task, learned words were recognized increasingly faster over time, indicating strengthening of their orthographic representations. This improvement was more pronounced for the group that learned with orthography. In the spoken word recognition task, however, a different pattern emerged. During the immediate session, no clear difference was observed between both types of words, while in the delayed session longer times were observed for the known words.

Such a result was surprising, but one likely explanation might be the known words set including both highly frequent and very low-frequency items, which might have blurred

possible RTs differences during the immediate session. During the delayed session, children had to provide an answer to the learned words (that had been lexicalized) and very low-frequency words, which may have led them to take more time to provide an answer. As observed the learned words did show a difference in RTs in the spoken word recognition task that emerged when considering learning modality. Thus, the results of the analyses comparing the RTs of known and learned words confirm that lexicalization happened.

Worthy to highlight, the visual group presented the most pronounced effects on RTs overall. These children responded faster in the written lexical decision task and slower in the spoken word recognition task, which is consistent with the nature of each task. In the written task, children were encouraged to respond quickly when recognizing a word, whereas in the spoken word recognition task, which used the Go/No-Go paradigm, they must withhold responses until they are certain, which naturally led to longer RTs if words are not common (i.e., low-frequency and novel learned words). These findings suggest that orthography takes the lead to lexicalizing the otrhographic and phonological representations of a word.

That orthographic information helps to improve the ability to recognize the form of words is consistent with previous findings in both children (Melamed et al., 2024; Valentini et al., 2018) and adults (J. Nelson et al., 2005). In the present study, we extend this evidence by showing that orthography provides an advantage from the very first encounter with a word (i.e., lexical configuration), strengthening not only orthographic but also phonological representations over time (i.e., lexicalization).

Now, the integration of semantic representations revealed a divergence between modalities. In the semantic masked priming task, only the oral learning condition demonstrated a delayed priming effect, whereas the visual learning group did not exhibit a statistically significant priming effect despite numerically faster responses to related targets. These results were unexpected as there is no reason to think that if orthography allows for a more efficient

lexicalization of orthographic and phonological representations it would not do the same to contribute to the integration of semantic representations.

One possible explanation might be related to the observed difficulty in children from low-SES backgrounds to extract meaning from written text (Oakhill et al., 2012). It is possible that learning through print placed higher demands on these children, making it more difficult to integrate orthographic, phonological, and semantic information within a single learning session. When learning occurs through print, attention may be captured primarily by the visual and form features of the word, leaving fewer cognitive resources available for constructing semantic connections. In contrast, oral input may more naturally encourage the formation of links between phonology and meaning. Because spoken input is transient, once the auditory signal disappears, learners may be more strongly compelled to rely on contextual information to construct meaning. That is, children in the oral group may have exerted greater effort to connect the novel words to the contextual information provided in the sentences. Because each target word appeared within a meaningful context that explicitly specified its semantic category, this effort may have promoted stronger phono-semantic associations when words were learned orally.

The specificity of French may explain why phonology did not produced as much improvement as orthography to acquire the form representations of words. In French, oral processing can be particularly demanding due to its phonological complexity; the grapheme-phoneme correspondences are more transparent than the phoneme-grapheme correspondences. Thus, it is very likely that French children benefitted more from orthography to generate phonological representations than from the phonology to generate orthographic representations of novel words. That is, children may still be generating orthographic skeletons (Wegener et al., 2023), as words became lexicalized regardless of the learning modality but the overall

superiority of the group that learned with orthography leaves this question open, as it may reflect language-specific properties.

The congruent- and cross-modality lexicalization effects observed in the present study extend the results of Bakker et al. (2014) with adults. Here, children also presented signs of lexicalization of the phonological and orthographic representations of novel words, as indexed by congruent and cross-modality tasks, regardless of the input modality. Importantly, and in contrast to Bakker et al., in the present study the effects emerged without drawing attention to one particular aspect of the word (e.g., orthography, phonology, etc.). That is, by exposing children to words embedded in context, without directing children's attention towards the words (see Tamura et al., 2017), and by comparing two different modalities, we avoided biases towards the acquisition of one lexical representation over the other.

Previous studies examining learning of novel words trained either in spoken or written modalities in children supported the role of orthographic input to infer meaning (Melamed et al., 2024; Valentini et al., 2018). However, a common shortcoming of these studies is that they did not include lexicalization measures (i.e, lexical effects), which are critical for evaluating the actual integration of words into the lexicon. In the present study, the masked priming paradigm revealed that oral input led to semantic lexical facilitation. Since Melamed et al. and Valentini et al. did not use this kind of measures, these results do not encounter their conclusions. In fact, our results concur with their findings that orthography helps to better recall and recognize newly learned words. Yet, when it comes to the integration of words into semantic networks, our results suggest that oral information supports lexicalization of semantic representations better. Given the masked paradigm, children in our study were unlikely to have been consciously aware of the learned words serving as primes or of their relationship with the targets, which were based on purely semantic rather than associative links (See Tamminen & Gaskell, 2013, for a discussion).

These findings enrich prior research on word learning and lexical development, particularly regarding the stages of configuration and lexicalization (Davis & Gaskell, 2009; Leach & Samuel, 2007). According to this framework, the integration of a novel word into the lexicon happens in two stages. First, lexical configuration, when the initial form and meaning are established, and second, lexicalization, when the word becomes integrated within the existing lexical network (Davis & Gaskell, 2009; Leach & Samuel, 2007). The present results provide empirical support for this theoretical distinction, showing that newly learned words behave different immediately after learning and one week later, consistent with the progressive transition from configuration to lexicalization.

A more recent account by Gaskell (2024) argues that hippocampal and cortical systems supporting these stages interact more dynamically than previously assumed, depending on the type of information being processed and the nature of the task demands. Although the present study was conducted prior to the publication of this framework, its findings do not conflict with it. On the contrary, it might pave the way for further investigation into whether learning modality modulates the relative engagement of these complementary systems. This could help explain why orthographic exposure seems to preferentially strengthen form (orthographic and phonological) representations, whereas oral exposure may facilitate stronger links to semantic information.

Taken together, these results suggest that the establishment of lexical representations may involve different contributions from oral and written modalities at different stages of learning. Our findings indicate that orthographic input is particularly effective for acquiring the orthographic and phonological representations of words while oral input seems to promote stronger semantic integration, as it provoked significantly stronger semantic priming over time. The specificity of French can be controlled in future studies by manipulating levels of orthographic transparency and the semantic information provided in each modality.

Considering the apports of each modality to lexical development observed in the present study, it may be conjectured that efficient word learning involves an initial orthographic exposure to "configure" the novel item, with a subsequent reinforcement through phonological input, which enables the lexicalization of the phonological code generated during orthographic processing (e.g., in the case of French). This process would eventually strengthen connections to semantic networks. Notably, lexicalization happened with a single training session, and it was evident after a week in the absence of additional exposure, highlighting the robustness of the effects which may support the potential efficiency of teaching words in such a sequential fashion.

Importantly, despite evidence that children from disadvantaged backgrounds benefit less from orthographic input (Maguire et al., 2018), our results suggest that these children can nevertheless acquire new vocabulary under a highly demanding learning regime. As noted in the introduction, children from low-income backgrounds typically present lower levels of vocabulary than their peers from higher-income backgrounds and vocabulary is a well-stablished predictor of academic success because of its close relationship with reading ability. Hence, children from disadvantaged backgrounds often face reading difficulties that stem not from cognitive or linguistic deficits, but from limited lexical knowledge. Including these children in vocabulary learning research is therefore mutually beneficial. On the one hand, such studies can contribute to a better understanding of vocabulary learning mechanisms, which could help to reduce social and educational inequalities. On the other hand, they broaden the scope of empirical research by focusing on populations that are often underrepresented. Furthermore, because these children are less likely to know the target words in experimental tasks, they provide a reliable context for studying word learning. Understanding how to facilitate the integration of new words into memory may ultimately help narrow socio-economic disparities in educational outcomes.

7.2.6.3 Limitations and future studies

Some limitations are to be considered in this study. First, the absence of a baseline measure hinders direct assessing of how the to-be-learned words behaved prior to training. Even though we ensured that the words were not known in our sample by piloting both the target words and their descriptions with children of the same age as our participants but from higher-SES backgrounds and by confirming with teachers that none of the words had been introduced in the curriculum during the current school year, future studies may benefit from including pre-exposure measures to better analize the unknown-to-configuration step.

Second, the sentence judgment task lacked sensitivity to capture semantic learning. As the task was designed specifically for this study, we realized afterwards that certain items classified as incorrect could nevertheless be judged as plausible (e.g., *I can go to the school in saiga*). This ambiguity raises the possibility that children's responses reflected judgments of sentence plausibility rather than evaluations of semantic appropriateness. Future research may therefore benefit of validated measures of semantic integration like picture naming, meaning–word matching or semantic categorization tasks.

Finally, since orthography exposure supported durable learning of orthographic and phonological word representations and oral input facilitated semantic integration after a single encounter, future research should evaluate whether sequential presentation of modalities enhances vocabulary acquisition and, if so, which order of presentation proves most effective. That is, whether introducing orthography before oral input, or vice versa, yield stronger lexicalization effects.

7.2.7 Conclusion

In conclusion, the modality through which a word is first encountered shapes its learning trajectory. Orthography appears particularly effective for establishing durable word forms, whereas oral input seems to support the integration of semantic information after a week.

Together, these findings may support that a strategic combination of modalities could foster the development of strong lexical representations, with important implications for both theory and educational practice.

7.3 Study 3 – Comparing Written vs. Sequential Written and + Oral Input

7.3.1 Introduction

In the previous study, we examined whether learning modality influences the development of lexical representations by comparing children exposed only to oral or written modality. The results showed that orthographic exposure alone facilitates more the acquisition of a word's form aspects, while oral exposure appears to support stronger semantic integration. Based on these findings, we proposed that efficient word learning in French might involve the complementary contributions of both modalities, with orthography initially supporting the configuration of new lexical items and phonological exposure reinforcing lexicalization over time. This interpretation raised the question of what happens when both modalities are used together, as they often are, in educational contexts, for example. If orthography is sufficient to establish orthographic and phonological representations and phonology leads to stronger semantic links, should both modalities be presented simultaneously, sequentially, or may a single modality be sufficient for effectively incorporating a new word into the lexicon? With this in mind, we sought to address the specific contribution of phonology.

The benefit of orthography to facilitate word learning is well known already. Extensive literature demonstrates that orthographic information can enhance the acquisition of new lexical representations (i.e., Orthographic Facilitation; Ricketts et al., 2009, 2021, 2015; Chambré et al., 2017; Jubenville et al., 2014; Rosenthal & Ehri, 2008; Salins et al., 2023; see Colenbrander et al., 2019 for a review). However, in most of these studies phonological and orthographic information is presented simultaneously, making it difficult to determine the independent contribution of each modality. At the same time, other studies, including our previous study (Study 2), suggest that orthography alone may be sufficient for acquiring a word's form (Valentini et al., 2018). If this is the case, the additional contribution of phonological information remains uncertain.

In a previous study, MacKague et al (2001) provided evidence that children in the third grade benefit from prior oral exposure to a word when reading it for the first time in print. The authors were questioning predictions made by different reading models (Coltheart & Rastle, 1994; Seidenberg & McClelland, 1989), but they did not explain why this occurs except to say that "such prior knowledge of phonological information might support the subsequent learning of explicit grapheme-phoneme correspondence rules" (McKague et al., 2001, p. 258). In a subsequent study, Johnston et al. (2004), offered an explanation, showing that literate individuals can generate orthographic representations only through exposure to the phonological forms of new words. The authors highlight these findings as evidence of the important role that orthography plays in language processing after the alphabetic principle has been acquired. This formed the basis for the Orthographic Skeleton Hypothesis (Wegener et al., 2018), which we discussed in Chapter 4. According to this hypothesis, when children hear a new word, they generate tentative orthographic representations based on their knowledge of spelling–sound mappings. In this study, we investigated whether presenting phonological information prior to written input would improve orthographic or semantic learning in children.

To address this question, the present study adopted an experimental design in which all children were exposed to all words under two learning conditions. One was a visual condition alone (orthography only; O condition). The other was a visual condition preceded by an oral presentation (P then O condition). With this design, we sought to isolate the specific contribution of phonological input to the word learning process. Specifically, we aimed to determine whether prior exposure to the spoken form of a word affects the effectiveness of lexical integration, beyond the articulatory facilitation observed in McKague et al.(2001). We examined whether exposure to the phonological form of a word before encountering its written form would facilitate the retrieval of word form information (phonological and orthographic

representations) more readily, as it would be expected given the OS hypothesis, and whether such a sequential presentation could enhance semantic integration.

One question that can arise regarding the impact of modality on word learning in alphabetic languages concerns the consistency of grapheme-phoneme conversion (GPC) and phoneme-grapheme conversion (PGC). GPC refers to the degree to which graphemes (spellings) map onto phonemes (sounds), while PGC refers to the degree to which phonemes map onto graphemes. In languages with more consistent GPC, it may be easier for children to retrieve phonological information from orthographic exposure because it can provide effective cues for establishing phonological and orthographic representations of newly learned words (Seymour et al., 2003). In their original study, Ricketts et al. (2009) found that orthography benefited the learning of both consistent and inconsistent words as measured by word-image matching. However, they found that orthography significantly improved the production of inconsistent spellings. These results suggested that orthographic facilitation may be particularly helpful when spelling patterns are difficult to infer from phonology alone, as is often the case in English. In a further study, Jubenville et al. (2014) showed that French-speaking monolingual children exhibited more orthographic facilitation for consistent items.

In a more recent study, Ricketts et al. (2021) evaluated whether the GPC would moderate the orthographic facilitation effect. Using more accurate measures for word learning over time than in previous studies, they did not observe an interaction between orthography and consistency. These mixed findings leave open the question of whether orthographic consistency interacts with orthographic facilitation. Considering that French presents an important asymmetry between GPC and PGM, these remarks are noteworthy. GPCs in French are relatively reliable, enabling readers to easily derive phonological information from written forms. In contrast, PGMs are considerably less predictable. Hearing a word does not lead to a unique orthographic form. This asymmetry suggests that written input may provide particularly

informative cues for establishing lexical representations, whereas phonological input alone may leave greater uncertainty about spelling. Consequently, orthographic information may play an integral role in establishing stable lexical representations during word learning, similar to the role of the combination of phonological and orthographic information.

7.3.2 Research questions and hypotheses

The present study examined then the effects of phonological exposure prior to written exposure when learning novel words. Specifically, we sought to determine whether hearing a word before seeing its written form would strengthen the acquisition of word forms and facilitate semantic learning or produce no measurable advantage compared to orthographic exposure alone.

Due to the sequential nature of the P-then-O condition, there are several possible outcomes. First, prior phonological exposure may facilitate the configuration of the phonological representation of the word, which can be reinforced by subsequent orthographic information. In Study 2, the benefit from orthography alone occurred and could be more easily mapped onto its form using the prior phonological input, as it can be predicted by the OS hypothesis (Wegener et al., 2018). According to this possibility, it would be reasonable to expect that the P-then-O condition would result in more efficient lexical development than orthographic exposure alone. This would lead to higher accuracy in the immediate session and stronger lexical effects over time in orthographic and phonological tasks.

However, considering the characteristics of the French writing system, a second possibility is that children may more readily recover phonological information from written input through grapheme-phoneme conversion processes during orthographic exposure, since the system is more transparent in that sense. Additionally, since phoneme-grapheme correspondences are less predictable, hearing words may not provide enough information to infer their orthographic forms. Because of this asymmetry, orthographic exposure alone may

provide the necessary phonological information to establish robust lexical representations, as observed in Jubenville et al. (2014). In this case, phonological prior exposure would not offer additional benefits, and orthographic exposure alone would suffice to support lexical configuration and the lexicalization of a word's orthographic and phonological representations. In this scenario, no significant differences would be expected between the O and P-then-O conditions.

Finally, prior oral exposure may be enhanced by orthography to facilitate the lexicalization into semantic networks. In our previous study, oral exposure alone resulted in stronger semantic integration than orthographic exposure alone. Therefore, we would expect that encountering novel words in context through the written modality would also provide the opportunity to acquire orthographic representations and link them to semantic representations. This is reasonable to expect given that orthographic forms can directly connect to semantic representations once the word is sufficiently defined (Harm & Seidenberg, 2004). If phonological information helps activate semantic representations prior to orthographic learning, presenting phonology before orthography could facilitate establishing semantic links. According to this hypothesis, stronger semantic priming effects could emerge over time in the P-then-O condition than in the O condition, reflecting enhanced semantic integration.

7.3.3 Method

7.3.3.1 Participants

Participants were 97 fourth- and fifth-grade students. Due to missing data, analyses were conducted for 86 participants (M Age = 10.5; SD = 0.53) from five classes in two low-SES schools in France. School SES was indexed using the Social Positionning Index (Dauphant et al., 2023). The participating schools had IPS scores well below the national mean (M = 104; present study population's IPS M= 72.15), ensuring that participating children were drawn from similar low-SES environments. All participants spoke French as their primary language.

7.3.3.2 Procedure

There were two lists containing the 16 target words (Appendix 4). In List A, the first eight words were presented in the visual-only—with orthography (O)—condition, and the remaining eight were presented in the phonology-then-orthography (P-then-O) condition. In List B, the order was reversed, with the first eight words presented in the P-then-O condition and the remaining eight in the O condition. Each class was randomly assigned to one of the two lists.

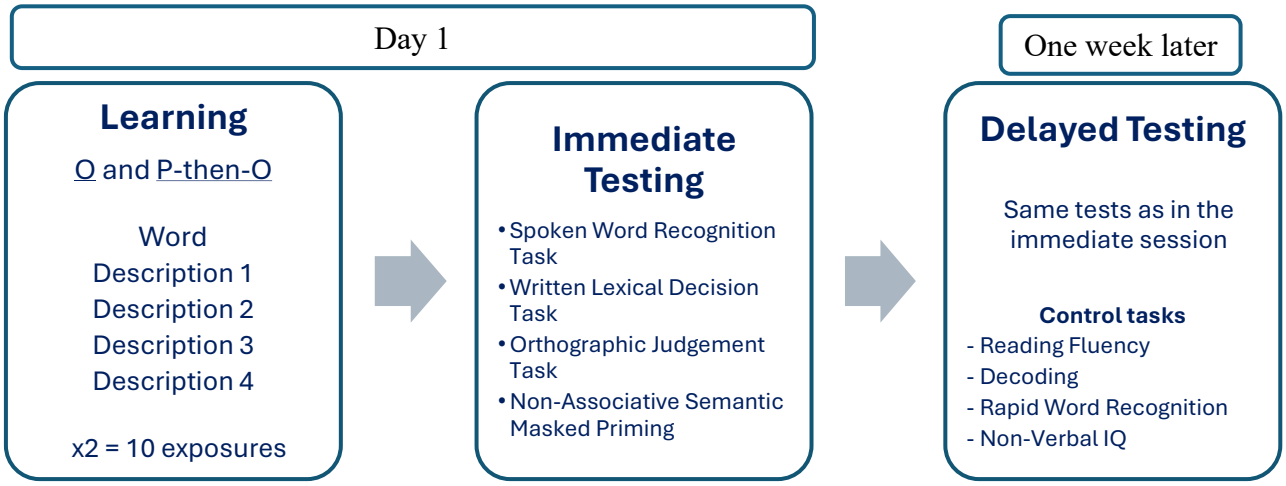
Regardless the list they got assigned, each child received a booklet containing all sixteen words and their descriptions. Each page displayed one word followed by four descriptive sentences about it. When a class was assigned to list A, after reading the first 8 words and their descriptions once, the children were instructed to close the booklet and listen to the teacher or a researcher (who was a native French speaker) to read out loud the other 8 word (during which the booklet was closed. They only listened.) After that, they were instructed to open the booklet again and start over reading all the words. This procedure ensured that each word was encountered 10 times in total.

When assigned to list B, the whole class first listened to their teacher or a researcher each of the eight target words and read their descriptions aloud. After hearing these eight words and descriptions, the children received the booklet and were instructed to read the remaining eight words from the O condition. Once they had finished reading this second set, they were instructed to start the booklet over from the beginning. Thus, the words in the P-then-O condition were read for the first time after being heard, while the words in the O condition were read for the second time. Like this, all words were encountered a total of 10 times across modalities.

In both conditions, children were informed that they would later be tested on the words they were learning; however, no explicit attention was drawn to any particular feature (e.g., orthographic or phonological) of the words. The experiment consisted of two sessions,

summarized in . During the first session, children completed the learning phase followed by the immediate testing comprising the experimental tasks. The second session took place one week later, including the experimental tasks and the control tasks. The booklet-based tasks were always administered before the computer-based tasks.

Figure 6
Description of Protocol in Study 3



7.3.4 Results

All analyses were conducted in Jamovi 2.6 (The jamovi project, 2024) and mixed effects models were fitted using the GAMLj package (Version 3.6; Gallucci, 2019). Preliminary correlational analyses were conducted on the background measures to avoid potential collinearity among the predictors. Rapid word recognition was significantly correlated with fluency (r = .74, p < .001) and decoding (r = .32, p < .01). Therefore, to reduce collinearity, fluency and decoding were excluded from further analyses.

In order to ensure task compliance, participants with an accuracy rate below 60% on the known words in the written lexical decision and in the semantic priming in general, were excluded from the analyses. For the Spoken Word Recognition task, which used a Go/No-Go procedure, participants with a hit rate below 55% or a false alarm rate above 60% were excluded. RT analyses were conducted only on correct responses. Trials with RTs shorter than

200ms or exceeding ±2 SDs from each participant's mean were excluded to avoid the influence of extreme outliers (2008). Across tasks, these exclusions never surpassed 5% of trials.

All experimental analyses were conducted using mixed-effects models (Baayen et al., 2008; Jaeger, 2008), with session (immediate vs. delayed) and learning (O vs. P-then-O) as fixed effects. The semantic priming task included an additional factor of relationship. Rapid word recognition and Raven's matrices were included as covariates in all the models. However, when their inclusion did not significantly improve the models' fit, they were removed (Barr et al., 2013). This will be signaled when appropriate. Random intercepts were always included for participants and targets. Table 11 presents children's performance on the experimental tasks involving the learned words. All subsequent analyses reported here were conducted on these data. Statistical sensitivity was ensured by collecting a large number of observations per task (Brysbaert & Stevens, 2018). Considering data collection in schools, the number of observations is significant, ranging from 8,257 to 22,279 trials for the spoken word recognition and semantic priming tasks, respectively. Confidence intervals were obtained by calculating 1000 bootstrap samples.

Table 11

Descriptive statistics for the experimental tasks by session and learning condtion.

Task	Session	Learning Condtion	Accuracy		Reaction Time (ms)		Relationship
			Mean	SD	Mean	SD	
Spoken Word Recognition	Immediate	O	0.62	0.49	1212	250	-
		P-then-O	0.66	0.47	1194	248	-
	Delayed	O	0.74	0.44	1203	272	-
		P-then-O	0.78	0.41	1172	239	-
Written Lexical Decision	Immediate	O	0.81	0.39	947	273	-
		P-then-O	0.74	0.44	971	282	-
	Delayed	O	0.83	0.37	869	282	-
		P-then-O	0.81	0.39	888	265	-
Orthographic Judgment	Immediate	O	0.82	0.38	-	-	-
		P-then-O	0.75	0.43	-	-	-
	Delayed	O	0.80	0.40	-	-	-
		P-then-O	0.76	0.43	-	-	-

Task	Session	Learning Condtion	Accuracy		Reaction Time (ms)		Relationship
			Mean	SD	Mean	SD	
Semantic Masked Priming	Immediate	O	0.89	0.32	922	268	R
					917	277	NR
		P-then-O			920	272	R
					910	267	NR
	Delayed	O	0.87	0.34	893	251	R
					904	271	NR
		P-then-O			903	271	R
					899	264	NR

Note. RTs are in milliseconds; R = Semantically related priming; NR = Non-semantically related priming; SD = Standard deviation.

7.3.4.1 Analysis of phonological processing

Table 12 presents the results for the model fitted to the accuracy data in the spoken word recognition task.

Table 12

Model For Accuracy in the Spoken Word Recognition Task

Fixed Coefficients				Random Effects			
Parameters	Estimate	SE	z	Groups	Name	Variance	SD
(Intercept)	1.08	0.19	5.73	**Participant**	(Intercept)	1.14	1.07
Session	0.81	0.12	6.97				
Learning	0.27	0.11	2.39	**Target**	(Intercept)	0.25	0.50
RWR	0.03	0.01	2.60				
Raven	0.01	0.04	0.04	**Residual**		3.29	1.81
Session*Learning	0.04	0.22	0.19				

Note. RWR = Rapid Word Recognition; SE = Standard Error.

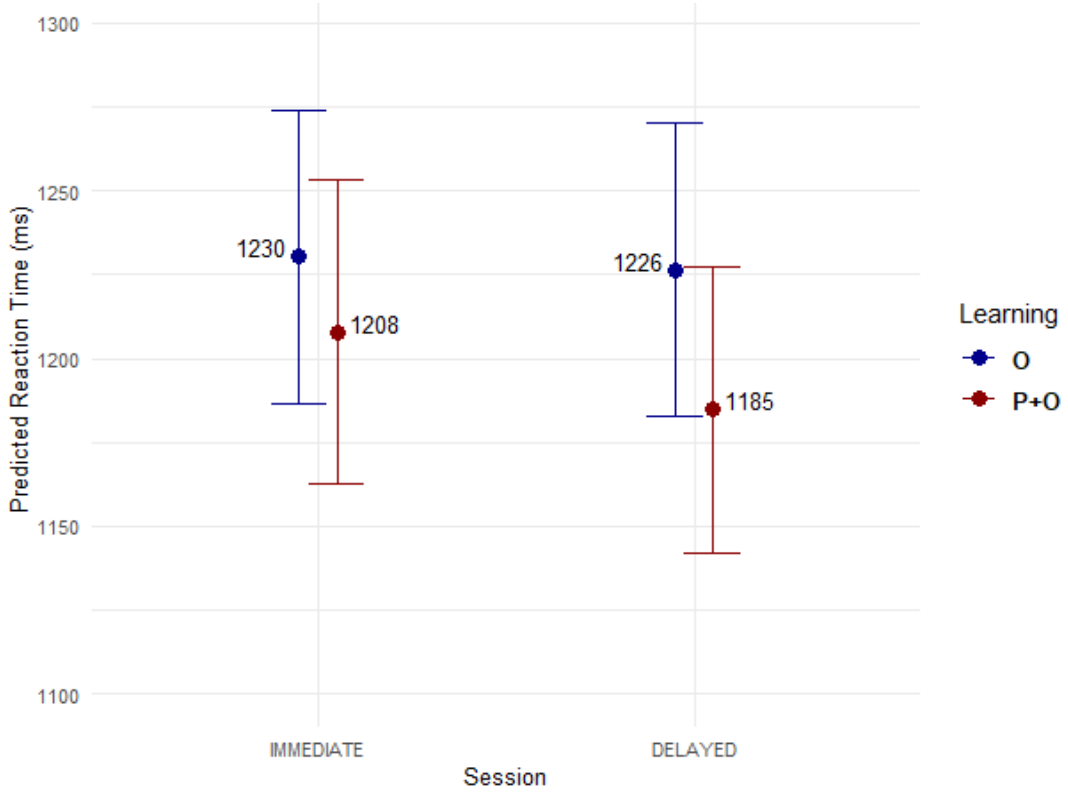
7.3.4.1.1 Spoken Word Recognition - Accuracy

A significant main effect of Session was observed, χ^2 (1) = 48.60, p <.001. Accuracy was higher in the delayed session regardless of the word learning regime (OR = 2.26, 95% CI [1.81, 2.85]). The main effect of Learning was significant, χ^2 (1) = 5.70, p < .05; with higher accuracy when the words were learned in the P-then-O condition (OR = 1.30, 95% CI [1.03, 1.63]). The interaction between Session and Learning was not significant, χ^2 (1) = 0.03, p = .852.

7.3.4.1.2 Spoken Word Recognition - RT

The model fitted for RTs in the spoken word recognition task revealed only a significant effect of session χ^2 (1) = 9.80, $p < .01$, indicating faster responses in general during the delayed condition (β = 32ms). Neither learning condition p = .17 nor the interaction p = .35 were significant. **Figure 7** presents the estimated marginal means (EMMs) derived from the model.

Figure 7
Estimated Marginal RTs in the Spoken Word Recognition Task by Learning condition and Session.



O= Words Learned under the written modality (with Orthography). P+O = Words learned in the Phonology-then-Orthography condition. Error bars indicate 95% confidence intervals.

7.3.4.2 Analysis of orthographic processing

Table 13 presents the results for the models fitted to accuracy in the written lexical decision and the orthographic judgment tasks.

Table 13

Models for accuracy in the orthographic tasks

Fixed Coefficients				Random Effects			
Parameters	**Estimate**	**SE**	**z**	**Groups**	**Name**	**Variance**	**SD**
			Written Lexical Decision				
(Intercept)	1.74	0.21	8.31	Participant	(Intercept)	0.97	0.99
Session	0.42	0.14	3.06				
Learning	0.35	0.13	-2.67	Target	(Intercept)	0.37	0.61
RWR	0.03	0.01	3.24				
Raven	0.08	0.04	1.86	Residual		3.29	1.81
Session*Learning	0.34	0.26	1.29				
			Orthographic Judgment				
(Intercept)	1.65	0.21	7.83	Participant	(Intercept)	0.67	0.82
Session	0.06	0.11	0.53				
Learning	0.41	0.11	3.85	Target	(Intercept)	0.52	0.72
RWR	0.03	0.01	4.04	Residual		3.29	1.81
Raven	0.07	0.03	2.30				
Session*Learning	0.24	0.21	1.16				
(Intercept)	1.65	0.21	7.83	Participant	(Intercept)	0.67	0.82
Session	0.06	0.11	0.53				

Note. Parameters correspond to: (1) Intercept; (2) Learning modality (Visual – Oral); (3) Session (Delayed – Immediate); (4) Learning Modality × Session interaction.

7.3.4.2.1 Written Lexical Decision – Accuracy

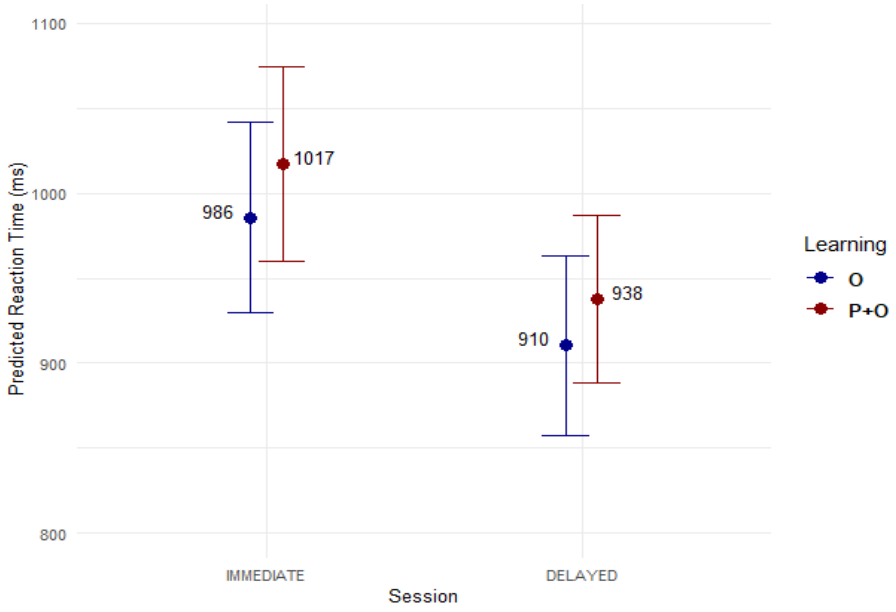
The model for accuracy in the written lexical decision task revealed a significant effect of session, χ^2 (1) = 9.38, p < .01, indicating higher overall accuracy in the delayed session (OR = 1.52, 95% CI [1.15, 1.99]). There was also a significant effect of learning, χ^2 (1) = 7.11, p < .01, indicating that participants in the O condition were more accurate overall (OR = 0.71, 95% CI [0.54, 0.92]). The interaction between learning and session was not statistically significant, p = .198.

7.3.4.2.2 Written Lexical Decision – RT

The model fitted for the RTs in the written lexical decision dropped the Raven variable. It yielded a significant effect of session χ^2 (1) = 55.84, p < .001, with faster responses in the delayed session (β = 77.40ms). There was also a significant effect of learning χ^2 (1) = 8.60, p < .01, with words learned in the O condition showing faster responses overall (β = 29.34ms). No significant interaction was observed, χ^2 (1) = 0.06, p = .810. **Figure 8** illustrates the estimated marginal means obtained from the model.

Figure 8

Estimated Marginal RTs in the Written Lexical Decision Task by Learning condition and Session.



O= Words Learned under the written modality (with Orthography). P+O = Words learned in the Phonology-then-Orthography condition. Error bars indicate 95% confidence intervals.

7.3.4.2.3 Orthographic Judgment

The model for the orthographic judgment task revealed a significant effect of learning, χ^2 (1) = 14.86, $p < .001$, indicating a better performance with the words learned in the O condition across sessions (OR = 0.67, 95% CI [0.54, 0.82]). Session effect was not observed, $p > .60$. Interaction between learning and session was not observed either, $p = .245$.

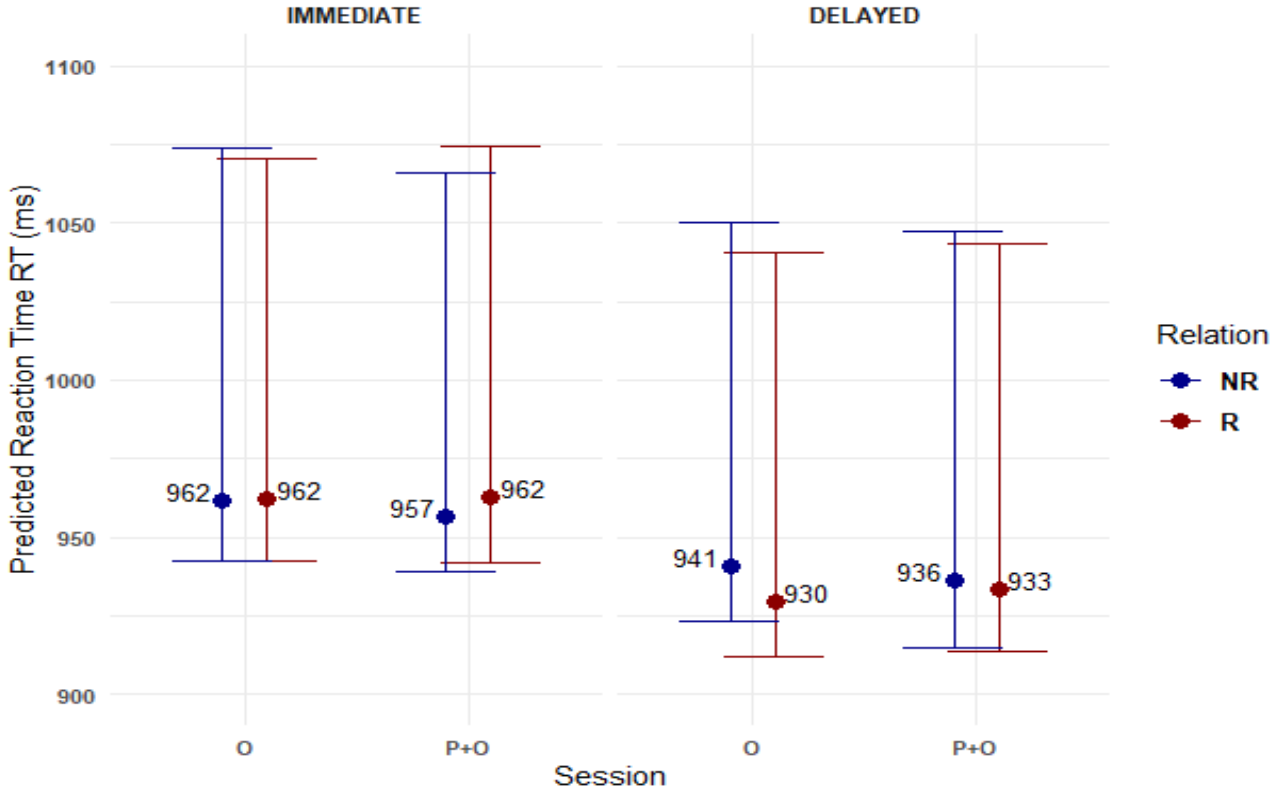
7.3.4.3 Analysis of semantic processing

7.3.4.3.1 Semantic Masked Priming

The model for the semantic masked priming revealed a significant effect of session χ^2 (1) = 76.92, $p < .001$, indicating that responses were significantly faster in the delayed session than in the immediate session (β = 25.64ms). No other main effect proved significant with *ps* > .52. A significant Session x Relation interaction, χ^2 (1) = 9.95, $p < .005$, indicated that the difference between related and unrelated trials increased at the delayed session, (β = 10.26ms). A Learning

x Relation interaction was also observed χ^2 (1) = 5.92, $p < .05$. However, since any of these two factors was significant, no conclusions can be drawn. The three-way interaction between Session, Relation, and Learning was not significant, $p = .896$. **Figure 9** shows the estimated marginal means derived from the model.

Figure 9
Estimated Marginal RTs in the Masked Semantic Priming Task by Session, Learning Condition, and Semantic Relation.



O= Words Learned under the written modality (with Orthography). P+O = Words learned in the Phonology-then-Orthography condition. NR= Non-Semantically Related Condition. R= Semantically Related condition. Error bars indicate 95% confidence intervals.

7.3.5 Discussion

This study examined whether exposure to the phonology of a word before seeing it in print helps children learn that word. Specifically, we wondered if such exposure influences the configuration and lexicalization of words among French-speaking children. Therefore, children were exposed to rare new words under two learning conditions: orthography alone (O) or

phonology preceding orthography (P-then-O). A set of tasks assessing orthographic, phonological, and semantic representations allowed us to evaluate the lexical development of the newly learned words. The results across the tasks indicate that presenting phonology before the written form of a word does not systematically enhance acquisition of that word's representations. These results are discussed in comparison to those from study 2, as well as in regard to their potential contribution to research on the role of modality in lexical acquisition.

Previous research suggests that modality plays a role in the lexical integration process (Bakker et al., 2014; Melamed et al., 2024; J. Nelson et al., 2005; Valentini et al., 2018; Van Der Ven et al., 2015), and the previous study presented in this manuscript (Study 2) revealed that oral and written modalities differently impact the integration of a word. In that study, learning through written input was observed to more readily support the acquisition of phonological and orthographic representations, whereas oral exposure seemed to facilitate the integration of words into semantic networks in children.

Considering that word were presented in two modalities in this study, compared to only one modality per group in study 2, it would have been natural to expect a better lexical development in the P-then-O condition. Morevover, if we consider Ehri's theory of word learning (Ehri, 1992), in which orthography input provides an opportunity to create direct connection to semantics with a more readily integration through phonology (Bakker et al., 2014; Valentini et al., 2018; Vargas-Cuevas, Javourey-Drevet, et al., 2026) it would have been evident that phonology and orthography would produce a stronger semantic effect implying a better lexicalization. Nonetheless, regarding orthographic and phonological representations, learning through orthography alone produced similar results to those obtained when phonological exposure preceded orthography, and no clear effects were observed from these learning conditions for semantic representations.

In the orthographic lexical decision task, the O condition led to better overall performance, as evidenced by higher accuracy and faster reaction times. However, both conditions resulted in lexicalization, as demonstrated by improved recognition of written words in the delayed session. The same was true in the orthographic judgment task, in which the O condition led to higher accuracy overall. These results are consistent with those of Study 2 and support the idea that exposure to the written form plays a prominent role in French word learning. In Study 2, children learned novel lexical items more efficiently through written exposure alone, which support the development of orthographic and phonological representations even in the absence of prior phonological input. The current study extended this research by examining whether prior phonological exposure would enhance the learning process when combined with written presentation. However, the results indicate that this sequential presentation did not produce stronger learning outcomes than orthography alone.

French orthography, while not fully transparent, nevertheless allows children to derive phonological information from written forms with a reasonable degree of consistency (Jubenville et al., 2014). As a result, children who encounter a novel written word may be able to generate its phonological form through decoding processes, even without prior auditory exposure. Thus, like Ricketts et al. (2021) suggested, it might be the case that the orthography of the novel words allowed for the acquisition of the word form to a point that cannot be much improved.

The P-then-O condition only yielded better performance, with higher overall accuracy, in the spoken word recognition task. However, both learning conditions produced similar improvements in children's ability to orally recognize the learned words over time. Regarding RTs in the same task, both modalities resulted in faster responses in the delayed session. Together with the improvement in recognition over time, these results suggest that the words were phonologically integrated regardless of learning condition.

Thus, unsurprisingly, when children heard a word in the P-then-O condition, they could identify it immediately. However, what is remarkable is that after one week, exposure to orthography alone produced similar results to those of the P-then-O condition. This finding aligns with Bakker et al. (2014) and our previous study showing that orthographic representations require a week to trigger lexical effects in oral tasks.

The specificity of the French language may explain why phonology does not enhance the acquisition of word forms beyond what orthography does. According to the orthographic skeleton hypothesis (Wegener et al., 2018), children can quickly develop preliminary orthographic representations based on pronunciation alone. However, generating orthographic representations from phonological forms may be particularly challenging in French due to the language's phonological complexity. Grapheme-phoneme correspondences are more transparent than phoneme-grapheme correspondences. Children may be generating orthographic representations (McKague et al., 2001; Wegener et al., 2018), but these representations may be unstable due to the irregularities of the French language. The sudden presentation (close in time) of the orthography probably causes children to focus on the orthographic representation, as in Study 2, thereby disrupting the connection to semantics.

Indeed, despite evidence of form learning, the absence of semantic priming effects indicates that the conditions tested in this study did not fully allow for the integration of the newly acquired words into semantic networks. We used the same semantic masked priming task as in Study 2. This task typically captures the interaction between semantically related concepts, which is often considered evidence of lexicalization. In the previous study, this task demonstrated that exposure to phonology alone resulted in a significant priming effect after one week. Therefore, the lack of such effects in the present study suggests that, in French, phonology creates a direct link to semantics more readily when presented alone.

7.3.5.1 Limitations and future directions

A couple of limitations of the present study should be considered for this study. First, the study did not include a baseline measure of participants' familiarity with the novel words prior to training. Like in study, 2, this was on purpose in order to avoid any contact with the words that could contaminate the configuration measures. Second, the lack of a phonology alone condition to have a clear picture of how such a sequential exposure is actually impacting the lexicalization process.

Future research should further investigate how the temporal organization of phonological and orthographic input influences lexical acquisition. One promising direction would be to compare sequential and simultaneous presentation of spoken and written forms in order to determine whether integrating both modalities at the same moment facilitates lexical learning. Additionally, reversing the order of presentation, that is, introducing orthography before phonology, could help clarify whether early orthographic exposure shapes subsequent phonological representation building.

One more possibility would be examining these processes across different languages. This could help determine whether the relative contributions of phonological and orthographic input change as a function of the transparency of the GPCs and PGCs.

7.3.6 Conclusion

In conclusion, the present study provides evidence that prior phonological exposure to novel written words does not substantially enhance lexical development. This finding may support the idea that exposure to words through written material is sufficient to facilitate this process in French-speaking children who have learned to read. Adding phonological information before written exposure did not provide measurable advantages for establishing orthographic, phonological, or semantic representations. From an educational perspective, the results suggest that increasing exposure to written material could be an effective way to promote

vocabulary growth. Such exposure may particularly benefit children from low socioeconomic backgrounds, who often have fewer opportunities for lexical exposure outside the classroom.

SECTION 3

GENERAL DISCUSSION AND CONCLUSION

Chapter 8: General Discussion

Learning words is one of the most important aspects of acquiring a language and developing essential language-related skills, such as reading, which are necessary for thriving throughout life. According to some estimates, we continue to learn at least one new word every two days until late adulthood (Brysbaert et al., 2016). Initially, word learning occurs primarily through oral exposure to new words. However, literacy instruction introduces words in print, making reading a major source for learning words (Cunningham, 2005). Given this shift and that opportunities to encounter words in print are not equal for all children, we examined the role of learning modality in children reaching the end of reading acquisition. The current chapter, divided into three sections, considers the entirety of the work carried out. First, there is a brief overview of each study and their results. Then, the implications of the findings regarding research on children's vocabulary and lexical development and the acquisition of high-quality lexical representations are discussed. Finally, we acknowledge some limitations and possibilities for future directions.

8.1 Recap across the three studies

The overarching goal of this thesis was to deepen our understanding of vocabulary and word-learning processes in primary school children. More specifically, the current research agenda examined the impact of SES on children's vocabulary knowledge, and most importantly, the influence of different learning modalities on lexical development. Through this work, we aimed to contribute to the broader fields of language and literacy research and ongoing discussions about evidence-based approaches to vocabulary instruction in educational settings.

To this end, three school-based studies were conducted with over 400 children in 4th and 5th grade (ages 9 to 11). Such studies were designed to reach specific theoretical objectives, including (1) examining how SES influences breadth and depth of vocabulary, (2) characterizing how orthographic, phonological, and semantic representations develop and

evolve over time across learning modalities, and (3) investigating how oral and written learning modalities contribute to word-learning trajectories from initial lexical configuration to later lexicalization.

The first study (n = 212) compared the performance of children from low- and high- SES on test evaluating the two domains of vocabulary, breadth and depth. Particular attention was given to vocabulary depth in order to determine whether SES influences the quality and organization of lexical knowledge beyond its well documented effect on vocabulary size.

The second study (n = 107) investigated the impact of learning modality on lexical development. Specifically, it examined how orthographic, phonological, and semantic representations of newly learned words were established and integrated into the lexicon when words were encountered through either oral or written input.

The third study (n = 97) further explored the role of modality by focusing on the contribution of phonological input during word learning. In this study, children learned new words either through orthographic exposure alone or through sequential exposure in which the phonological form of the word was presented before its written form. This design allowed us to examine the contribution of prior exposure to the phonology of words to the word-learning process as well as to determine whether sequential exposure to phonology followed by orthography would support lexical acquisition more effectively than orthography alone. These last two studies were conducted with children from low-SES backgrounds.

8.2 Summary of Key Findings

Study 1 revealed that SES, as measured by the socioeconomic background of the school, affected breadth and depth independently. Specifically, we observed that SES significantly impacted vocabulary depth, even after controlling for breadth. Study 2 showed that modality can impact the integration of word representations (i.e., orthography, phonology, semantics). Specifically, we found that learning through written material facilitated the acquisition of a

word's form, whereas learning through speech produced stronger evidence of semantic integration after one week. Finally, Study 3 demonstrated that orthographic exposure alone produced learning outcomes comparable to those observed following sequential phonological and orthographic exposure. In other words, prior exposure to the phonological form of a word did not substantially enhance the acquisition of word representations.

Taken together, these findings call for thinking about the modality in which children encounter and learn words children's as well as considering vocabulary not only in terms of quantity, but also of the quality of lexical representations.

8.3 Theoretical Implications

8.3.1 A matter of vocabulary depth and high-quality lexical representations

Learning a word implies acquiring knowledge of its orthographic, phonological, and semantic representations. Before learning to read, children primarily acquire vocabulary through oral exposure. That is, they can link the semantic representation directly to the phonological representation they hear when interacting with others around them (Carey & Bartlett, 1978). Once children learn to read, they gain the opportunity to learn words by interacting with written materials (Cunningham, 2005; Nagy et al., 1985). This is argued to be so because written input provides a mnemonic anchor for generating an orthographic representation and the ability to retrieve phonological and semantic representations (Ehri, 1992; Share, 1995, 2008b). This aligns with the LQH (Perfetti & Hart, 2002), according to which a word must have detailed, well-integrated, and flexible orthographic, phonological, and semantic representations in order to be well-known and useful for comprehension. For example, when a child knows the word "sapote" and has a high lexical representation of it, the orthographic form can activate the phonological form and the associated semantic network.

The LQH emphasizes high-quality lexical representations given their importance for reading comprehension. The higher the quality of a lexical item, the easier it is to recognize,

and the more connected it is to other words, which facilitates the reading process (Perfetti, 2007; Perfetti & Hart, 2002; Perfetti & Stafura, 2014). In other words, a higher-quality lexical item provides greater depth of vocabulary knowledge. Considering the distinction between vocabulary breadth and depth, in which breadth represents the size of one's vocabulary (i.e., the number of words one knows), and depth represents the structure and organization of those words (i.e., detailed knowledge of words) (R. Anderson & Freebody, 1981; Meara & Wolter, 2009; Webb, 2012), as well as their unique contribution to reading comprehension (Cain & Oakhill, 2014; Ouellette, 2006; Tannenbaum et al., 2006), the relationship becomes more clear.

In Study 1, we present evidence that SES significantly impacts not only breadth but also depth of vocabulary (Vargas-Cuevas, Facon, et al., 2026). This is relevant because most studies examining the effect of SES on children's vocabulary primarily consider measures of vocabulary size (see Neuman et al., 2018, for example). Consequently, the conclusions drawn from such studies may be limited to vocabulary breadth. In our study, we also found that the impact of SES on vocabulary depth depends on the tasks used. Our synonyms task, which evaluated interlexical relations, revealed a direct impact of SES on depth, even after controlling for breadth. By contrast, our attributes task, which evaluated detailed knowledge of words, revealed that the impact was moderated by breadth. While some authors argue that distinguishing between vocabulary breadth and depth is unnecessary (Vermeer, 2001), our findings suggest that it is important to consider both aspects, as well as the measures we use, when addressing children's vocabulary.

Tasks that do not consider children’s contexts may overlook knowledge that is not valued by the academic system. This is also related to how vocabulary size is often estimated more by receptive than productive measures (Schmitt, 2014). Nonetheless, receptive vocabulary typically exceeds expressive vocabulary throughout one's lifetime (Anglin et al., 1993; Brysbaert et al., 2016). Thus, using a receptive test with "standardized words" to evaluate the

vocabulary of children who have not had the same opportunities for vocabulary acquisition may provide an incomplete representation of their lexical knowledge and underestimate their vocabulary strengths. For this reason, it would be better to first take into consideration other factors (individual and environmental) that might impact the results on a given test and second use a dynamic approach that captures a child's partial knowledge of words (see Ricketts et al., 2021, for an example). Essentially, when working with children whose development is typical and ruling out any impairment, for which standardized tests are, of course, very useful, considering ways to evaluate the quality of lexical representations may be the best approach. As Perfetti and Hart stated, "Not individuals, but word representations vary in quality."(2002, p. 192).

With this in mind, one possible explanation for the impact of SES on vocabulary depth is that children from lower-SES backgrounds are exposed to less rich and varied language (Hart & Risley, 1995; Hoff, 2006; Nag, 2023; Rowe, 2012). Such limited exposure can reduce not only the quantity of words with which they are familiar, but also the opportunities to strengthen semantic relationships in their existing vocabulary. Thus, a reasonable question that may arise is what conditions allow children to acquire high-quality lexical knowledge that contributes to the depth of their vocabulary, making it well-interconnected and useful for comprehension and ongoing learning. There are certainly many possibilities. We examined the impact of modality on the integration of lexical representations over time, as a first step to word learning.

8.3.2 Modality as an entry point for the lexicalization of high-quality lexical representations

In alphabetic languages like French and English, speech sounds (phonemes) are represented by letters (graphemes). When children learn to read, what they learn is the decoding principle, meaning that each letter or group of letters represents a sound from the spoken language (Byrne, 1998). In this way, it has been observed that children who already know how to read independently, in such languages, can use orthography to facilitate word learning,

especially the phonological and orthographic representations (i.e., Orthographic Facilitation; Ricketts et al., 2021, 2009; Rosenthal & Ehri, 2008; see Colenbrander et al., 2019, for a review). Similarly, it appears that they can generate orthographic representations after hearing a word by applying their knowledge of phoneme-to-grapheme mappings (i.e., Orthographic Skeletons; Wegener et al., 2018).

In the studies investigating the OF, the experimental paradigm consists of presenting always the phonology of the word, with the crucial manipulation being the presence (O+) or absence (O–) of orthography. This makes sense if we want to test the benefits of orthography in learning words and these studies have established the usefulness of presenting orthography when learning words (Colenbrander et al., 2019; Ricketts et al., 2009, 2021; Rosenthal & Ehri, 2008; Salins et al., 2023). However, children do not always have access to orthography in everyday life and even in class. At school, they hear many new words, especially if they come from low-income backgrounds, and unless these words are targeted for learning, they may not see them in writing. Yet, they learn them. Given the proposal of the OS, it may be the case that modality plays a role in the creation of new lexical representations when encountering completely novel words for the first time.

A common measure of word learning is the ability to retrieve the label associated with a given concept. This assessment, in its various formats (e.g., image-word matching, meaning retrieval, etc.), has been described as an indicator of both breadth and depth of vocabulary knowledge (Cain & Oakhill, 2014). In other words, it provides information about familiarity with words and, to some extent, detailed knowledge of them, especially when used dynamically (see Ricketts et al., 2021). Another way to assess whether a word belongs in the lexicon is to analyze the processes involved in acquiring it. The configuration and lexicalization framework (Davis & Gaskell, 2009; Leach & Samuel, 2007) allows us to measure not only superficial knowledge of a word's form but also the interaction between lexical representations. This

interaction is crucial to determining the quality of a lexical representation. Evaluating this process was deemed it could shed light on how modality impacts word learning.

8.3.2.1 The role of orthography

The results from Studies 2 and 3 thus extend the proposal of the OF by showing that orthography alone is already very useful to acquire orthographic and phonological representations of words. Indeed, in the paradigms used to assess the OF, the simultaneous double presentation of orthography and phonology (O+P+) might be at the origin of the benefice of the use of orthography. Here we show that orthographic alone is already helpful for showing evidence of lexicalization.

A compelling explanation for the OF effect during word learning is that orthography enables the encoding of phonological information and thus prompts the enhancement of orthographic and phonological representation acquisition through the alphabetic principle. According to this idea, the degree of consistency in the GPC could moderate the OF effect. In this sense, consistent stimuli will make orthography a more reliable cue to phonological and semantic word representations (Ricketts et al., 2021). In a previous study evaluating OF, Jubenville et al. (2014) controlled for consistency in their stimuli and found that French-speaking children presented with consistent orthographic forms demonstrated greater orthographic facilitation than those presented with inconsistent forms (Experiment 1). In our study, the material was fairly consistent, and the children's primary language was French. As we did not manipulate consistency, we cannot draw conclusions in this regard. However, given the consistency of the French language in terms of GPCs and the conditions of our study, it is reasonable to think that this is why orthography was more useful.

Yet, Jubenville observed an inverse pattern in their second experiment with English-French bilinguals. They observed that these children benefited more from orthography when the to-be-learned words had inconsistent GPC. More recently, Ricketts et al. (2021) found no

interaction between orthographic presence and consistency. They had anticipated a stronger OF effect when the words were consistent. This led them to acknowledge that the opposite could also occur, with inconsistent items standing out more, thereby getting more attention and producing stronger OF. This is in line with Jubenville's (2014) conclusion for their second experiment. Another interesting alternative proposed by Ricketts et al. (2021) is that orthographic learning for consistent items in the orthography-absent condition could already be quite high thanks to OS. According to this account, the possible OS generated leave little room for improvement when words are consistent, making then the presence of orthography particularly beneficial for inconsistent words as their spelling patterns are harder to infer from phonology.

Although this possibility is appealing, we cannot fully adhere to it, given the results presented in this thesis. On the one hand, if this were the case that children are generating orthographic representations, and given that our material was consistent, we should have observed similar patterns when we compared orthography and phonology in Study 2. However, this was not the case. On the other hand, when we tested presenting phonology prior to orthography, we did not observe much of a difference in the lexical development of novel words, compared to orthography presented alone. Thus, Studies 2 and 3 highlight that orthography facilitates the acquisition of novel words more readily than phonology alone and yields as much learning as the two modalities presented sequentially, at least with regard to orthographic and phonological representations.

The results of Studies 2 and 3 are consistent with previous findings indicating that written information is more effective than oral information in facilitating the acquisition of orthographic and phonological word representations (Tamura et al., 2017; Valentini et al., 2018; Van Der Ven et al., 2015). Furthermore, our results extend previous findings in two ways. First, using real words, we demonstrate that, like adults (Bakker et al., 2014), children can create

cross-modal representations after incidental exposure (Study 2) (see Tamura et al., 2017 for an example of same-modality representations). Second, we assess the integration of novel words more deeply by using measures that evaluate lexicalization. Unlike Valentini et al. (2018), who examined orthographic, phonological, and semantic representations but only measured one point in time (i.e., immediately after learning), thereby obtaining information only about word configuration.

Thus, the results regarding the benefits of orthography for acquiring orthographic and phonological representations are consistent across studies. These results align with accounts that emphasize the importance of recoding phonological information while reading (i.e., Self-teaching Hypothesis; Share, 1995, 2008b) and the significant role that orthography plays in language processing once reading has been acquired (Grainger et al., 2005; Ziegler et al., 2004; Ziegler & Ferrand, 1998). Conversely, the results regarding semantic learning are more conflicting. Some studies have shown that written material alone facilitates the acquisition of semantic representations more effectively (Melamed et al., 2024; J. Nelson et al., 2005), while other have not (Suggate et al., 2013). Even the OF has not always been observed for acquiring semantic representations (Colenbrander et al., 2019), suggesting that the word learning process may vary by modality. This is important because, as previously discussed, knowing only a word's form accounts only for vocabulary breadth. The most important aspect of vocabulary when it comes to reading is having words of high lexical quality that allow for a high level of vocabulary depth.

8.3.2.2 The role of phonology

In Studies 2 and 3, we found no statistically significant evidence of semantic priming when learning words from written material alone. Instead, we observed this effect following phonological exposure alone (Study 2). These findings are somewhat in line with those of Suggate et al. (2013), who found that oral exposure to stories yielded better performance on

picture word recognition tasks than written exposure did. Leach and Samuel (2007) noted in their study that training with semantics (e.g., picture associations or full stories) produced stronger evidence of configuration and lexicalization than training with the phoneme monitoring paradigm. Furthermore, Henderson et al. (2013) demonstrated that children exhibited stronger lexicalization effects when semantic information was available. Since our material was semantically rich, consisting of detailed descriptions of each word, we may speculate that semantic representations are more easily linked to phonology than to orthography which facilitates the connection between phonology and semantics when encountering novel words orally.

This must be considered carefully. It is by no means suggested that orthography is not connected to semantics. Of course it is, once word recognition becomes automatic following sufficient exposure. Many theories of reading explain this, including the LQH (Perfetti, 2007; Perfetti & Hart, 2002; Perfetti & Stafura, 2014), the Self-Teaching hypothesis (Share, 1995, 2008b) and the most prominent models of reading development (Coltheart et al., 2001; Grainger et al., 2005; Harm & Seidenberg, 2004). Instead, the argument here is that, when encountering a novel word alongside rich semantic information for the first time, phonology appears to promote a more direct connection to the semantic network. This is evidenced not only by our results in French, but also by those of Leach and Samuel (2007), Suggate at al. (2013) and other several studies that have studied lexicalization using oral training paradigms along with semantic information (Henderson, Weighall, & Gaskell, 2013; James et al., 2019; Takashima et al., 2017; Weighall et al., 2016).

Two possible explanations may account for these results. First, the transient nature of spoken input may encourage learners to rapidly extract meaning from the available semantic information. When children were exposed to the novel words in Study 2, they may have prioritized establishing semantic links because the phonological stimulus was brief and could

not be revisited. In this sense, learners may have engaged in a form of fast mapping without visual referents. For example, if “sapote” was described as a fruit, this semantic information may have been integrated immediately. By contrast, during written exposure children may have focused more strongly on the orthographic form of the word, potentially allocating fewer cognitive resources to processing the accompanying semantic information. It is also possible that children struggle to fully comprehend during reading, or that the amount of information presented created a degree of cognitive load.

Another possibility relates to the bimodal activation model (Grainger et al., 2005) and the “division of labor” between phonological and orthographic information to get to semantics proposed by Harm and Seidenberg (2004). From this perspective, phonological input may have facilitated access to semantics because of the relatively transparent orthography of the stimuli. If children generated orthographic representations while hearing the words, they may have been able to link the phonological input to semantic representations through orthography. However, if this were the case, one might expect a stronger semantic priming effect in the sequential condition of Study 3, where phonological exposure was followed by orthographic presentation. This pattern did not emerge. Consequently, although the generation of orthographic representations cannot be ruled out, the fast-mapping explanation remains a plausible account of the observed results.

Yet, the possibility of generating OS cannot be ruled out. In fact, this possibility could help explain the seemingly contradictory result of weaker semantic priming effects in the sequential presentation of phonology and orthography. Tamura et al. (2017) reported that a greater number of exposures to target words was necessary before lexicalization effects could be detected. Similarly, Bakker et al. (2014) observed that orthographic representations took longer to show evidence of lexicalization than phonological ones. In Study 3, exposure to orthography decreased. Therefore, it is possible that children generated OSs during

phonological exposure; however, the subsequent orthographic presentation may have interfered with or reorganized the emerging representations rather than strengthening semantic connections immediately, likely due to the imbalance between GPC and PGM in French. A final alternative is that orthography introduced additional processing demands that impaired phonology's contribution to semantic integration afterwards.

8.3.3 Final considerations across studies

Considering the observation in Study 1 that SES can impact vocabulary depth, as well as the impact of modality reported in Studies 2 and 3, in which orthography and phonology were compared both separately and in a sequential presentation, measuring not only configuration but also lexicalization in children, certain points might be worth highlighting.

First, the results from Study 1 emphasize the importance of considering both the quantity and depth of vocabulary knowledge when evaluating vocabulary development in children from diverse backgrounds. This study showed that differences associated with socioeconomic context may be reflected in both the number of words children know and the richness and organization of their semantic representations. Second, the findings in Studies 2 and 3 underscore the relevance of learning modality as a factor that influences the integration of new words into the mental lexicon. These studies suggest that orthographic and phonological input contribute differently during the early stages of word learning and that the modality through which words are first encountered may influence the processes involved in lexical configuration and lexicalization. Over all, they converge in showing that orthography was enough to allow children to acquire orthographic and phonological representations supports the argument that orthographic information plays an important role for word learning in literate children (Ehri, 2014; Ricketts et al., 2009; Rosenthal & Ehri, 2008). Nevertheless, the nature of the relationship between phonology and semantic integration remains open. The present findings therefore raise further questions regarding how phonological and orthographic information interact during the

early stages of lexical development, and how these interactions may influence the quality of emerging lexical representations. Third, the results may suggest that language-specific characteristics must be considered when examining word learning processes. The relative contribution of orthographic and phonological information may vary depending on the properties of the writing system, such as orthographic transparency and the relationship between written and spoken forms.

8.4 Limitations and Future Research

The present research agenda has certain limitations that must be acknowledged. These limitations relate to measurement choices, the assessment of SES, and aspects of the experimental designs implemented across studies. First, some of the measures used to assess vocabulary depth and semantic knowledge were specifically designed for each study. While the measures used in Study 1 demonstrated acceptable reliability, validation is needed. In Study 2, this resulted in a measure that did not capture the intended semantic knowledge. Thus, other measures that consider contextual use of words, possibly including production measures, might be beneficial in the future. A second limitation of Study 1 concerns the measure of SES. Since SES was operationalized at the school level rather than the individual level, effects associated with children's own socioeconomic background may be difficult to distinguish from effects associated with school environments. This distinction is important because differences in school characteristics may account for some of the observed effects. Previous research in English-speaking contexts has shown that SES is associated with variability in instructional quality and language-learning opportunities (Buckingham et al., 2013; Neuman et al., 2018). While all French schools adhere to the same national curriculum, unmeasured school-level factors, such as variations in pedagogical practices or instructional resources, cannot be entirely dismissed (Faivre, 2021; see Brossette et al., 2025 for the specific case of France).

In our background measures, we included reading and nonverbal IQ. However, including additional measures that provide a broader understanding of the children's profiles could help us better grasp the impact of modality on their word learning processes. As mentioned in the introduction, vocabulary is impacted by a myriad of factors, including individual (Cain et al., 2004; Matthews et al., 2018), cognitive (Bruce & Bell, 2022; Y.-S. G. Kim, 2017), linguistic (Baddeley et al., 1998b; Torgesen et al., 1997; Wagner & Meros, 2010) and environmental (Buckingham et al., 2013; Hoff, 2006; Neuman et al., 2018). Similarly, the absence of a baseline measure in Studies 2 and 3 may have prevented us from directly assessing the behavior of target words prior to training. This decision was intentional; the goal was to avoid any prior exposure that might have influenced the measurement of lexical configuration. Although we ensured the words were unfamiliar to the children by piloting the items with same-age peers from higher SES and confirming with teachers that the words were not introduced in the school curriculum during the school year of each study, a baseline measure would have permitted a more precise examination of the transition from unknown to lexical configuration.

Finally, Study 3 did not include a phonology-only condition, which limits our ability to isolate the contribution of sequential exposure to orthographic and phonological information during lexicalization. A more complete protocol that includes both modalities and control conditions would provide a clearer understanding of how different modalities independently and concurrently influence the lexical development process.

In general, future studies would benefit from using broader and more sensitive measures of word knowledge, especially assessments that capture semantic knowledge in greater detail. While the present research examined aspects of semantic associations and word relations, graded and contextualized measures could offer a clearer picture of how well newly learned words integrate into children’s lexical networks. Tasks that examine children's production may offer insight into the use of newly acquired words in meaningful contexts beyond mere

recognition or association. Such tasks could provide richer insight into the development of vocabulary depth and the functional use of lexical knowledge.

Further research could explore the modality of word presentation in more detail, including a wider range of ages, to study changes that occur during development, for example. Similarly, the order in which modalities are introduced during the learning process could be informative. The present studies examined the role of modality in lexical configuration and lexicalization. However, future work could investigate whether certain modalities are more effective at triggering lexical configuration and whether a different sequence of exposure (e.g., oral followed by written presentation) results in stronger lexical integration. Indeed, preliminary follow-up studies using a quite similar protocol like Study 3 in our laboratory controlling for type of presentation (sequential vs simultaneous) seem to point out towards an impact of these factors. Understanding how different modalities contribute at distinct stages of word learning may help identify optimal pathways for supporting vocabulary development. This topic will be discussed in the next chapter.

Finally, additional research is needed to examine the cross-linguistic effects of modality in word learning. Investigating how modality influences lexical development in languages such as French, English, or Spanish could clarify the roles of orthographic transparency and phonological consistency in the lexicalization process. Cross-linguistic comparisons would help determine whether the patterns observed in the present studies reflect language-specific characteristics or more general mechanisms of vocabulary acquisition.

Chapter 9: Practical implications of the current research agenda

School practices and the possibility to share with children the magic of words are the *raison d'être* of the whole research agenda presented here. So far, the discussion has focused on theoretical frameworks, models and hypotheses that aim to explain the process of learning words, which is normal in the context of a doctoral thesis that aims to deepen our understanding of vocabulary in children. However, as mentioned in the introduction, this research forms part of a broader initiative led by the French Ministry of Education to address educational inequalities. Specifically, the PIA 3 "*100% IDT: Inclusion, un Défi, un Territoire*" project brought together efforts from two regions in northern France to promote inclusion in schools while taking local contextual needs into account. As these regions are characterized by high levels of economic disadvantage, this thesis was framed within a project that explicitly aimed to reduce inequalities associated with, among other factors (e.g., handicap), socio-economic disparities. For context, nearly one in five people in the Nord and Pas-de-Calais departments live below the poverty line, representing 18% of the population. This figure is almost 3 percentage points higher than the national average in France (INSEE, 2026).

As discussed in Chapter 1, children from low SES often exhibit lower vocabulary knowledge, compared to their peers from higher SES, when assessed using standard measures. These differences are strongly associated with later academic achievement, which is linked to long-term socioeconomic outcomes. In this context, the practical objective of the present research was to lay the groundwork for word-learning strategies that teachers in low-SES school settings could implement and evaluate. More broadly, our project considered the importance of bridging the gap between research and educational practice. Such a connection has the potential to generate tangible benefits for children and teachers alike. In the end, teachers are the ones who work daily in complex educational environments and play a critical role in supporting children's language development.

Studies reviewing vocabulary training have indicated that teaching specific words does not always lead to positive word-learning outcomes (Cervetti et al., 2023). Furthermore, almost none of the studies reviewed in Cervetti et al.'s paper reported transfer to comprehension. Of those that did, the conclusion was that vocabulary interventions generally have a positive effect on comprehension outcomes, but only for passages containing the words taught during the interventions, which is in line with other reviews (Elleman et al., 2009; Stahl & Fairbanks, 1986; Wright & Cervetti, 2017). This can raise the question of whether using instructional time to teach specific words is useful, especially if the goal is to improve reading comprehension. This question seems legitimate given the above findings and fair claims that it is virtually impossible to explicitly teach all the words children need for keeping up in school (Nagy & Herman, 1984). However, there is something worth highlighting: The way vocabulary is conceived in these kinds of reports.

Many vocabulary-building programs focus on increasing the number of words children are familiar with by teaching their meanings (Cervetti et al., 2023; Marulis & Neuman, 2010). In other words, they focus only on vocabulary size, which might explain why no transfer to reading comprehension is observed. As we saw, vocabulary should be considered in terms of both breadth and depth (R. Anderson & Freebody, 1981; Ouellette, 2006), and it is the depth of vocabulary knowledge that more readily supports reading comprehension (Cain & Oakhill, 2014; Ouellette, 2006; Tannenbaum et al., 2006). Thus, the finding in Study 1 that SES impacts vocabulary depth as well as breadth makes us consider the potential value of interventions that address vocabulary depth, particularly for children from low-SES backgrounds.

One example of promising results regarding the impact of vocabulary depth training on reading comprehension in French-speaking children comes from the ProVoc app, developed by Potocki et al. (2021). In their study, the authors fostered vocabulary depth by asking children to actively interact with words, identifying their semantic features or linking words based on their

relationships. They also assessed the effects of this training on comprehension of texts that did not contain the trained words, as well as on the ability to infer information from text. In addition to improving the depth of vocabulary for the learned words, Potocki et al. observed significant improvements in reading comprehension, which they argue are likely due to the training on depth. Of importance to our argument, their study was carried out with children from low-SES backgrounds. This is in line with authors that recommend strategies that encourage that children explore the meanings, usage, and semantic relationships of words in different contexts to promote deep, long-lasting vocabulary learning (Beck et al., 2013).

Another clear practical implication of the work presented here is the use of orthography to establish solid knowledge of a word form. In line with the Orthographic Facilitation Hypothesis (Ricketts et al., 2009; Rosenthal & Ehri, 2008), orthography should be used to help children create robust orthographic and phonological representations. Regarding the emergence of semantic representations, however, oral exposure appears to be more effective. Thus, the strategic use of these two modalities could be considered. In French, as implied by Study 3 and follow-up studies in our laboratory, orthography should precede phonology (likely due to the particularities of the French orthographic system). Therefore, using the two modalities simultaneously or sequentially, with orthography first, might be effective. It should be noted though, that using phonology and orthography simultaneously does not always produce positive results in semantic learning, at least in English (Baese-Berk et al., 2025; Colenbrander et al., 2019; Leach & Samuel, 2007 (Study 4); but see Ricketts et al., 2021). The idea anyway is that the phonology of words could be used to integrate novel words into semantic networks once their form has been established.

In short, if any suggestions can be made given the fundamental nature of our results, it may be that words should continually be reinforced through interaction, regardless of how they are acquired. Children must be exposed to rich and varied language. This can be achieved

through reading and engaging them, as well as engaging with them, in discussions and situations that allow them to discover new words and facilitate the formation of new connections within their vocabulary.

Conclusion

Not all children have the same opportunities to acquire vocabulary given their socioeconomic backgrounds. These differences in resources lead to disparities in reading comprehension and the ability to grasp new knowledge from text. In the present work, we observed that SES impacts not only the breadth, but also the depth of vocabulary knowledge. Therefore, it is important to find ways to provide children with opportunities to acquire high-quality lexical representations, that is, words with stable orthographic, phonological, and semantic representations that are also flexible enough to be used in different contexts. This is an essential feature of vocabulary depth, meaning detailed knowledge of words and robust connections between them.

One possibility that could be considered is modality. Orthography is undoubtedly an effective way of acquiring knowledge of a word's form, that is, its orthographic and phonological representation. However, phonology appears to facilitate a more direct connection to semantics when sufficient semantic information is available. Therefore, to promote vocabulary depth and high-quality lexical knowledge, one approach could be to strategically use phonological and orthographic information to help children establish strong links to semantic networks and robust word forms. Such connections can be reinforced through exposure to varied language and interaction with others. Ultimately, this could help children who have fewer opportunities to encounter what is required in academic contexts to maintain their learning and reach their full potential, and, returning to the reference with which this manuscript began, avoid the catastrophe warned of by Cataure and Visitation.

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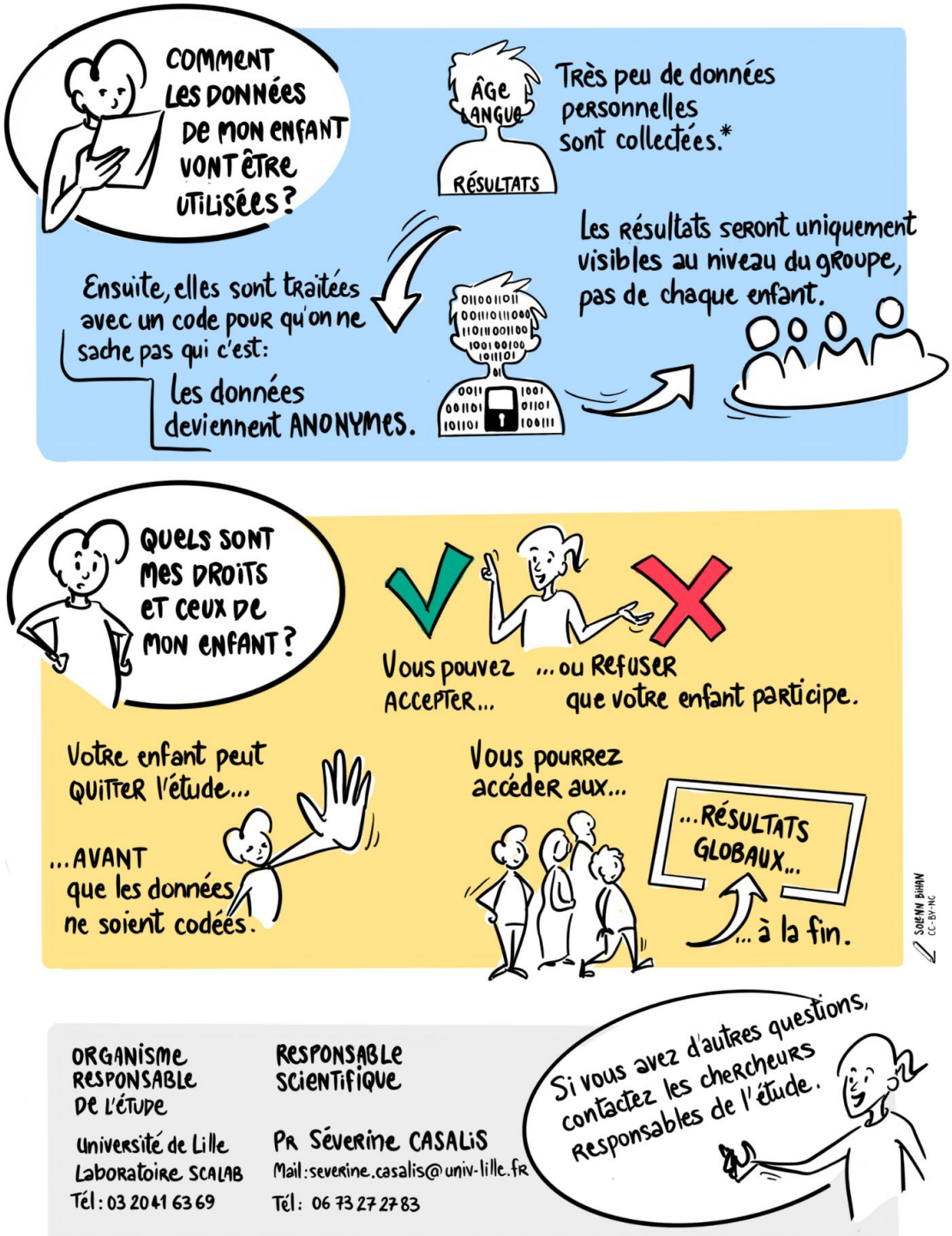
APPENDICES

Appendix 1. Simplified Information Letter


COMMENT LES DONNÉES DE MON ENFANT VONT ÊTRE UTILISÉES ?
ÂGE
LANGUE
RÉSULTATS
Très peu de données personnelles sont collectées.*
Ensuite, elles sont traitées avec un code pour qu'on ne sache pas qui c'est:
les données deviennent ANONYMES.
Les résultats seront uniquement visibles au niveau du groupe, pas de chaque enfant.
QUELS SONT MES DROITS ET CEUX DE MON ENFANT ?
Vous pouvez ACCEPTER...
... ou REFUSER que votre enfant participe.
Votre enfant peut QUITTER l'étude...
...AVANT que les données ne soient codées.
Vous pourrez accéder aux...
...RÉSULTATS GLOBAUX...
... à la fin.
SOENN BIHAN
CC-BY-NC
ORGANISME RESPONSABLE DE L'ÉTUDE
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Tél : 03 20 41 63 69
RESPONSABLE SCIENTIFIQUE
PR Séverine CASALIS
Mail : severine.casalis@univ-lille.fr
Tél : 06 73 27 27 83
Si vous avez d'autres questions, contactez les chercheurs responsables de l'étude.
* Pour les mentions RGPD, se référer à la lettre d'information complète à récupérer auprès de l'école.
Université de Lille

Appendix 2. List of words used in the Attributes and Self-Assessment of Vocabulary Knowledge tasks (Study 1)

Word	***Number of letters***	***Frequency***
Chou-fleur [cauliflower]	10	3
Carrelage [tiles]	9	3
Ventilateur [fan]	11	3.1
Kimono [kimono]	6	3.5
Gobelet [cup]	7	7.9
Loutre [otter]	6	8.9
Cravate [tie]	7	10.2
Ruche [beehive]	5	13.3
Poubelle [trash can]	8	21.5
Charrette [trolley]	9	28.9
Poire [pear]	5	29.9
Marteau [hammer]	7	34.3
Coquille [shell]	8	35.4
Haricot [bean]	7	36.7
Bonnet [beanie]	6	37
Crocodile [crocodile]	9	56
Montre [watch]	6	78.1
Oreille [ear]	7	289.7
Train [train]	5	326.9
Cheval [horse]	6	493.3

Appendix 3. Stimuli in the Rapid (1minute) Word Recognition Task

Moyenne	**chantigne**	**vome**	bouillante
machine	découvertes	immédiatement	exercices
armateur	horizontales	**pruc**	**binthéan**
curle	**naton**	inventions	laissant
constitue	asseoir	envoyant	**trameul**
marme	**zeu**	**bange**	soudain
alimentaires	serpents	rafales	boulette
sadre	**fuise**	**coume**	**pouteur**
flin	satisfaire	colères	**benian**
hain	**érune**	**safle**	gourmandise
hortaneur	**gimes**	feuilles	**perge**
maquettes	**tuney**	bourgeons	**setance**
anglaise	direction	**mironche**	**foupet**
blanche	monstrueux	allumer	confortablement
polaires	**chalgre**	**toère**	consultation
frabe	matière	compère	**noile**
lerge	lumineuses	**cagier**	étonnante
prein	**chuvin**	cependant	renvoyer
ufno	glissant	doutait	**morpe**
druvi	**camblumont**	**bleur**	oiseaux
pabis	**denge**	regardant	**tonfraile**
sonores	concurrents	ordinaires	**sorce**
certains	**vrotail**	brusquement	**folme**
vegade	**raupe**	extrémités	diriger
pondagne	**cacus**	malheur	**podogan**

Appendix 4. Learning Material for Studies 2 and 3

Word	Descriptions
Animals	
Marsouin [*Porpoise*]	Le marsouin est un animal marin qui ressemble à un dauphin. [*The porpoise is a dolphin-like marine animal.*]
	Le marsouin a un corps petit, arrondi, et un court nez. [*The porpoise has a small, rounded body and a short nose.*]
	Le marsouin produit des bruits très aigus pour se repérer dans l'espace et chasser. [*Porpoises use high-pitched noises to find their bearings in space and to hunt.*]
	Le marsouin vit en groupe de 5 à 10 et chasse des poissons. [*Porpoises live in groups of 5 to 10 and hunt fish.*]
Mergule [*Little Auk*]	Le mergule ressemble à un pingouin avec sa tête noire, sa poitrine blanche et son bec court et pointu. [*The little auk resembles a penguin with its black head, white breast and short, pointed beak.*]
	Le mergule est un petit oiseau marin qui vit en groupe dans l'hémisphère nord. [*The little auks are small seabirds that live in groups in the northern hemisphere.*]
	Les mergules ont un seul œuf en juin que les deux parents surveillent. [*The little auks have a single egg in June, which both parents look after.*]
	Le mergule plonge sa tête sous l'eau pour chasser des petits poissons. [The *Little auks dive their heads underwater to hunt small fish.*]
Mouffette [*Skunk*]	La mouffette a une fourrure de couleur noire, avec deux grands traits blancs sur le dos. [S*kunks have black fur with two large white stripes on their backs.*]
	La mouffette a une petite tête et une queue longue et épaisse. [*Skunks have a small head and a long, thick tail.*]
	La mouffette est un animal qui vit la nuit et se nourrit d'insectes, de fruits et d'œufs d'oiseaux. [*Skunks are nocturnal animals that feed on insects, fruit and bird eggs.*]
	Lorsque la mouffette se sent en danger, elle émet des grondements accompagnés d'une mauvaise odeur. [*When skunks feel they are in danger, they emit growls accompanied by a bad odor.*]
Saïga [*Saiga*]	Le saïga a deux cornes pointues et un corps comme une chèvre avec des poils blonds et courts. [*The saiga has two pointed horns and a goat-like body with short blond hair.*]
	Le saïga a un nez long et tombant sur la bouche comme une courte trompe. [*The saiga's nose is long and falls over the mouth like a short trunk.*]
	Le saïga est un animal qui court très vite et qui habite en Asie centrale. [*The saiga is a fast-running animal that lives in Central Asia.*]
	Le saïga est doté d'un très bon odorat et mange de l'herbe. [*The saiga has a very good sense of smell and eats grass.*]

Word	Descriptions
Clothing	
Caban [*Peacoat*]	Le caban est un manteau court, très chaud, utilisé par les marins. [*The peacoat is a short, very warm coat used by sailors.*]
	Le caban est souvent de couleur bleu foncé avec six boutons en deux rangées. [*The peacoat is often dark blue with six buttons in two rows.*]
	Le caban a un col large et il est fabriqué en laine. [*The peacoat has a wide collar and is made of wool.*]
	Le caban peut se mettre dans des conditions extrêmes de pluie, de vent et de froid. [*The peacoat can be worn in extreme conditions of rain, wind and cold.*]
Cardigan [*Cardigan*]	Le cardigan est un vêtement d'hiver qu'on porte en dessous du manteau. [*A cardigan is a winter garment worn under a coat.*]
	Le cardigan, comme le gilet, est fabriqué en laine et tricoté. [*Like the vest, the cardigan is made of wool and knitted.*]
	Le cardigan a des manches longues et se ferme avec des boutons devant. [*Cardigans have long sleeves and fasten with buttons at the front.*]
	Les cardigans se portent sur une chemise ou un Tee shirt et peuvent avoir des poches. [*Cardigans can be worn over a shirt or T-shirt and may have pockets.*]
Redingote [*Frock Coat*]	La redingote est un manteau long qui descend jusqu'aux mollets. [*The frock coat is a long coat that reaches down to the calves.*]
	Les manches de la redingote sont longues avec des boutons décoratifs aux poignets. [*The sleeves of the frock coat are long, with decorative buttons on the cuffs.*]
	La redingote est souvent portée lors des mariages, des cérémonies ou des soirées de gala. [*The frock coat is often worn at weddings, ceremonies and gala evenings.*]
	A l'origine, la redingote était utilisée pour monter à cheval. [*Originally, the frock coat was used for riding.*]
Sarrau [*Smock*]	Le sarrau est une courte et large blouse de travail que l'on porte au-dessus des autres vêtements. [*The smock is a short, wide work smock worn over other garments.*]
	Beaucoup de sarraus ont des poches à l'avant, utiles pour ranger les outils. [*Many smocks have front pockets, useful for storing tools.*]
	Les sarraus sont fabriqués dans des matières résistantes et faciles à nettoyer. [*Smocks are made from hard-wearing, easy-to-clean materials.*]
	Le sarrau est souvent porté par les paysans et les ouvriers pour protéger leurs vêtements. [*The smock is often worn by farmers and workers to protect their clothing.*]
Fruits	
Anone [*Custard Apple*]	L'anone est un fruit provenant d'un arbre exotique cultivé aux Antilles. [*The custard apple is a fruit from an exotic tree grown in the French West Indies.*]
	L'anone ressemble à une poire par sa forme et sa peau verte. Sa chair est de couleur blanche. [*The custard apple resembles a pear in shape and green skin. Its flesh is white.*]
	L'anone a un goût acide et sucré mais ses pépins noirs ne se mangent pas. [*The custard apple has an acidic, sweet taste, but its black seeds are not edible.*]
	L'anone est souvent préparée dans du yaourt avec des épices. [*The custard apple is often prepared in yogurt with spices.*]
	La curuba est un petit fruit qui vient d'Amérique du Sud. [*Banana passion fruit is a small fruit from South America.*]

Word	Descriptions
Curuba [*Banana Passion Fruit*]	La curuba a une forme allongée. Sa peau est jaune quand elle est mûre. [*Banana passion fruit has an elongated shape. Its skin is yellow when ripe.*]
	La chair de la curuba est de couleur orange. Elle a de petits pépins noirs comme le fruit de la passion. [*The flesh of the banana passion fruit is orange. It has small black seeds, like the passion fruit.*]
	La curuba est souvent utilisée pour faire des glaces. [*Banana Passion fruit is often used to make ice cream.*]
Durian [*Durian*]	Le durian est un gros fruit tropical originaire d'Asie. [*The durian is a large tropical fruit native to Asia.*]
	Le durian a une peau épineuse de couleur verte et jaune quand il mûrit. [*Its spiny skin is green and yellow when ripe.*]
	On mange la chair jaune du durian et ses graines grillés. [*The yellow flesh of the durian and its roasted seeds are eaten.*]
	Le durian est décrit comme un fruit délicieux malgré sa mauvaise odeur. [*Durian is described as a delicious fruit, despite its unpleasant odor.*]
Sapote [*Sapote*]	La sapote est un gros fruit d'un arbre tropical provenant d'Amérique Latine. [*Sapote is the large fruit of a tropical tree from Latin America.*]
	La sapote est vert foncé à l'extérieur avec une graine volumineuse, brune et brillante. [*Sapote is dark green on the outside, with a large, shiny brown seed.*]
	La sapote a une pulpe de couleur orange sucrée et crémeuse. [*Sapote has a sweet, creamy orange pulp.*]
	La sapote est consommée crue à la petite cuillère ou tartinée sur du pain. [*Sapote is eaten raw with a spoon or spread on bread.*]
Musical Instruments	
Biniou [*Bagpipe*]	Le biniou est un instrument de musique à vent qui produit un son aigu. [*The bagpipe is a wind instrument that produces a high-pitched sound.*]
	Le biniou a une poche en cuir qui se remplit d'air quand on souffle dedans avec un petit tuyau. [*The bagpipe fills with air when you blow into it with a small pipe.*]
	Quand on appuie sur la poche du biniou avec les bras l'air sort par d'autres tuyaux. [*When you press down on the pouch of a bagpipe with your arms, the air comes out through other pipes.*]
	On joue du biniou debout en groupe surtout en Bretagne. [*The bagpipe is played standing up in a group, especially in Brittany.*]
Bongo [*Bongo*]	Le bongo est un instrument à percussion d'Amérique Latine. [*The bongo is a Latin American percussion instrument.*]
	Le bongo est constitué de deux petits tambours en bois recouverts de peau. [*The bongo consists of two small wooden drums covered with skin.*]
	Le bongo se place entre les genoux du musicien qui frappe dessus. [*The bongo is placed between the knees of the musician, who strikes the drum.*]
	Le bongo permet de donner le rythme à la musique avec des sonorités joyeuses. [*The bongo gives rhythm to the music with its joyful sounds.*]
Cithare [*Zither*]	La cithare est un instrument de musique. On pince ses cordes avec les doigts ou les ongles. [*The zither is a musical instrument. Its strings are plucked with the fingers or fingernails.*]
	La cithare a une caisse sous ses cordes qui permet de faire résonner le son. [*The zither has a body under its strings that allows the sound to resonate.*]
	On joue de la cithare sur une table ou sur les genoux car elle n'a pas de manche. [*The zither is played on a table or on the knees, as it has no neck.*]

Word	Descriptions
	La cithare ressemble à une petite harpe avec des cordes de plus en plus petites. [*The zither resembles a small harp, with progressively smaller strings.*]
Clavecin **[*Harpsichord*]**	Le clavecin est un instrument de musique à clavier du XVIème siècle en Europe. [*The harpsichord is a keyboard musical instrument from 16th-century Europe.*]
	Le clavecin ressemble à un piano avec ses touches noires et blanches. [*The harpsichord resembles a piano, with black and white keys.*]
	Le clavecin est utilisé dans la musique classique et se joue assis. [*The harpsichord is used in classical music and is played seated.*]
	Le clavecin est fabriqué en bois et produit des sons assez doux. [*The harpsichord is made of wood and produces fairly soft sounds.*]

Appendix 5. Stimuli for the Spoken Word Recognition Task (Studies 2-3)

Type of Stimuli	Target	Type of Stimuli	Target
Learned Word	**Marsouin** [***Porpoise***]	Pseudoword	bisiau
Learned Word	**Mergule** [***Little Auk***]	Pseudoword	ceblere
Learned Word	**Mouffette** [***Skunk***]	Pseudoword	clacefon
Learned Word	**Saïga** [***Saiga***]	Pseudoword	mongi
Learned Word	**Caban** [***Peacoat***]	Pseudoword	luréon
Learned Word	**Cardigan** [***Cardigan***]	Pseudoword	cavute
Learned Word	**Redingote** [***Frock Coat***]	Pseudoword	acume
Learned Word	**Sarrau** [***Smock***]	Pseudoword	cucufé
Learned Word	**Anone** [***Custard Apple***]	Pseudoword	mergaon
Learned Word	**Curuba** [***Banana Passion Fruit***]	Pseudoword	marlouks
Learned Word	**Durian** [***Durian***]	Pseudoword	miandette
Learned Word	**Sapote** [***Sapote***]	Pseudoword	sabca
Learned Word	**Biniou** [***Bagpipe***]	Pseudoword	cabiz
Learned Word	**Bongo** [***Bongo***]	Pseudoword	rarrea
Learned Word	**Cithare** [***Zither***]	Pseudoword	reseltote
Learned Word	**Clavecin** [***Harpsicord***]	Pseudoword	carvidin
Distractor Word	Étier [*Channel*]	Pseudoword	érear
Distractor Word	Frêne [*Ash*]	Pseudoword	flène
Distractor Word	Chalutier [*Trawler*]	Pseudoword	gracutuer
Distractor Word	Enclume [*Anvil*]	Pseudoword	enfloge
Distractor Word	Campanule [*Campanula*]	Pseudoword	callanène
Distractor Word	Nourrice [Nanny]	Pseudoword	néorcife
Distractor Word	Moine [*Monk*]	Pseudoword	biane
Distractor Word	Truelle [*Trowel*]	Pseudoword	brielle
Distractor Word	Planète [*Planet*]	Pseudoword	chavête

Type of Stimuli	Target	Type of Stimuli	Target
Distractor Word	Théâtre [*Theater*]	Pseudoword	theptre
Distractor Word	Client [*Customer*]	Pseudoword	clieur
Distractor Word	Cirque [*Circus*]	Pseudoword	purque
Distractor Word	Cahier [*Notebook*]	Pseudoword	pahour
Distractor Word	Campagne [*Countryside*]	Pseudoword	cattable
Distractor Word	Habitant [*Inhabitant*]	Pseudoword	nacilant
Distractor Word	Magasin [*Store*]	Pseudoword	masanon

Appendix 6. Stimuli for the Written Lexical Decision Task (Studies 2-3)

Type of Stimuli	Target	Type of Stimuli	Target
Learned Word	**Marsouin** [***Porpoise***]	Pseudoword	aciat
Learned Word	**Mergule** [***Little Auk***]	Pseudoword	irede
Learned Word	**Mouffette** [***Skunk***]	Pseudoword	flabe
Learned Word	**Saïga** [***Saiga***]	Pseudoword	puifle
Learned Word	**Caban** [***Peacoat***]	Pseudoword	tranars
Learned Word	**Cardigan** [***Cardigan***]	Pseudoword	vobut
Learned Word	**Redingote** [***Frock Coat***]	Pseudoword	laple
Learned Word	**Sarrau** [***Smock***]	Pseudoword	padeur
Learned Word	**Anone** [***Custard Apple***]	Pseudoword	benian
Learned Word	**Curuba** [***Banana Passion Fruit***]	Pseudoword	ficolle
Learned Word	**Durian** [***Durian***]	Pseudoword	janard
Learned Word	**Sapote** [***Sapote***]	Pseudoword	trumin
Learned Word	**Biniou** [***Bagpipe***]	Pseudoword	avear
Learned Word	**Bongo** [***Bongo***]	Pseudoword	lobut
Learned Word	**Cithare** [***Zither***]	Pseudoword	viste
Learned Word	**Clavecin** [***Harpsicord***]	Pseudoword	impre
Distractor Word	Trousse [Case]	Pseudoword	nètel
Distractor Word	Créature [Creature]	Pseudoword	nacêre
Distractor Word	Palmier [Palm Tree]	Pseudoword	romte
Distractor Word	Dimension [Dimension]	Pseudoword	ogier
Distractor Word	Clairière [Glade]	Pseudoword	soroul
Distractor Word	Dehors [Outside]	Pseudoword	jarman
Distractor Word	Croquis [Sketch]	Pseudoword	péblon
Distractor Word	Ecolier [Schoolchild]	Pseudoword	nuireux
Distractor Word	Verger [Orchard]	Pseudoword	ompre

Type of Stimuli	Target	Type of Stimuli	Target
Distractor Word	Proverbe [Proverb]	Pseudoword	râchon
Distractor Word	Tiroir [Drawer]	Pseudoword	deltre
Distractor Word	Menuisier [Joiner]	Pseudoword	menté
Distractor Word	Bouleau [Birch]	Pseudoword	halme
Distractor Word	Dossier [Folder]]	Pseudoword	felge
Distractor Word	Foudre [Lightning]	Pseudoword	brosent
Distractor Word	Corbeille [Wastebin]	Pseudoword	asandé

Appendix 7. Stimuli for the Orthographic Judgment Task (Studies 2-3)

Learned Word	Number Of Letters	Orthogaphic Close	Number of Letters	Orthographic Distant	Number of Letters	Homophone	Number of Lettres
Marsouin [***Porpoise***]	8	masrouin	8	marlouez	8	marzouin	8
Mergule [***Little Auk***]	7	megrule	7	mentula	7	mergul	6
Mouffette [***Skunk***]	9	mouffetet	9	mouclaine	9	mouffete	8
Saïga [***Saiga***]	5	sïaga	5	sabca	5	sahiga	6
Caban [***Peacoat***]	5	cabna	5	cabiz	5	cabahn	6
Cardigan [***Cardigan***]	8	cadrigan	8	carcimun	8	cardiguen	9
Redingote [***Frock Coat***]	9	redignote	9	resembole	9	redingott	9
Sarrau [***Smock***]	6	sararu	6	samiez	6	sarro	5
Anone [***Custard Apple***]	5	anoen	5	acume	5	anaune	6
Curuba [***Banana Passion Fruit***]	6	curuab	6	cuvuli	6	curouba	7
Durian [***Durian***]	6	durain	6	duluen	6	duryen	6
Sapote [***Sapote***]	6	saptoe	6	saligu	6	sapotte	7
Biniou [***Bagpipe***]	6	binoiu	6	binant	6	binyou	6
Bongo [***Bongo***]	5	bonog	5	boncu	5	bongho	6
Cithare [***Zither***]	7	cithaer	7	citilu	6	citarre	7
Clavecin [***Harpsicord***]	8	calvecin	8	clacefan	8	clavessin	9

Appendix 8. Stimuli for the Semantic Masked Priming Task (Studies 2-3)

Semantic Category	Prime	Target	Relationship	Semantic Category	Prime	Target	Relationship
Animals	**Marsoin [*Porpoise*]**	Hibou [*Owl*]	R	**Fruits**	**Anone [*Custard Apple*]**	Orange [*Orange*]	R
		Dinde [*Turkey*]	R			Abricot [*Apricot*]	R
		Requin [*Shark*]	R			Ananas [*Pineapple*]	R
		Livret [*Booklet*]	NR			Caissier [*Cashier*]	NR
		Ouragan [*Hurricane*]	NR			Plombier [*Plumber*]	NR
		Triomphe [*Triumph*]	NR			Poteau [*Post*]	NR
	Mergule [*Litte Auk*]	Héron [*Heron*]	R		**Curuba [*Banana Passion Fruit*]**	Framboise [*Raspberry*]	R
		Aigle [*Eagle*]	R			Fraise [*Strawberry*]	R
		Sanglier [*Wild Boar*]	R			Citron [*Lemon*]	R
		Tribunal [*Court*]	NR			Coiffeur [*Hairdresser*]	NR
		Rectangle [*Rectangle*]	NR			Vinaigre [*Vinegar*]	NR
		Triangle [*Triangle*]	NR			Humain [*Human*]	NR
	Mouffette [*Skunk*]	Gorille [*Gorilla*]	R		**Durian [*Durian*]**	Raisin [*Raisin*]	R
		Hamster [*Hamster*]	R			Noisette [*Hazelnut*]	R
		Pigeon [*Pigeon*]	R			Prune [*Plum*]	R
		Incendie [*Fire*]	NR			Policier [*Policeman*]	NR
		Episode [*Episode*]	NR			Empereur [*Emperor*]	NR
		Alpiniste [*Alpinist*]	NR			Ciseau [*Chisel*]	NR
	Saïga [*Saiga*]	Hérisson [*Hedgehog*]	R		**Sapote [*Sapote*]**	Cerise [*Cherry*]	R
		Marmotte [*Marmot*]	R			Epinard [*Spinach*]	R
		Chenille [*Caterpillar*]	R			Olive [*Olive*]	R
		Rugby [*Rugby*]	NR			Plombier [*Plumber*]	NR
		Cérémonie [*Ceremony*]	NR			Vélo [*Bicycle*]	NR
		Magie [*Magic*]	NR			Charrette [*Cart*]	NR

Semantic Category	Prime	Target	Relationship	Semantic Category	Prime	Target	Relationship
Clothing	**Caban [*Peacoat*]**	Echarpe [*Scarf*]	R	**Music Instruments**	**Biniou [*Bagpipe*]**	Flûte [*Flute*]	R
		Foulard [*Neckerchief*]	R			Banjo [*Banjo*]	R
		Cravate [*Tie*]	R			Saxophone [*Saxophone*]	R
		Corbeille [*Wastebin*]	NR			Transport [*Transport*]	NR
		Sirop [*Syrup*]	NR			Chauffeur [*Driver*]	NR
		Poursuite [*Chase*]	NR			Douche [*Shower*]	NR
	Cardigan [*Cardigan*]	Bonnet [*Beanie*]	R		**Bongo [*Bongo*]**	Accordéon [*Accordion*]	R
		Chemise [*Shirt*]	R			Orgue [*Organ*]	R
		Casquette [*Cap*]	R			Tuba [*Tuba*]	R
		Tracteur [*Tractor*]	NR			Acteur [*Actor*]	NR
		Croquis [*Sketch*]	NR			Infirmier [*Nurse*]	NR
		Regret [*Regret*]	NR			Vendeur [*Salesman*]	NR
	Redingote [*Frock Coat*]	Culotte [*Underpants*]	R		**Cithare [Zither]**	Trompette [*Trumpet*]	R
		Pantalon [*Pants*]	R			Batterie [*Drums*]	R
		Robe [*Dress*]	R			Lyre [*Lyre*]	R
		Refuge [*Shelter*]	NR			Avocat [*Lawyer*]	NR
		Enfance [*Childhood*]	NR			Ingénieur [*Engineer*]	NR
		Adulte [*Adult*]	NR			Coupe [*Cut*]	NR
	Sarrau [*Smock*]	Gant [*Glove*]	R		**Clavecin [Harpsicord]**	Guitare [*Guitar*]	R
		Pull [*Pullover*]	R			Tambour [*Drum*]	R
		Jupe [*Skirt*]	R			Trombone [*Trombone*]	R
		Croissant [*Croissant*]	NR			Chanteur [*Singer*]	NR
		Méthode [*Method*]	NR			Serveur [*Waiter*]	NR
		Culture [*Culture*]	NR			Ecrivain [*Writer*]	NR

Note. R= Related NR= Non-Related

Appendix 9. Stimuli for the Sentence Judgment Task (Studies 2-3)

Learned Word	Congruent Phrase	Incongruent Phrase
Marsouin [***Porpoise***]	Il a déjà soigné un marsouin. [*He once nursed a porpoise.*]	Il mange souvent dans le marsouin. [*He often eats in the porpoise.*]
Mergule [***Little Auk***]	Je regarde un documentaire sur le mergule. [*I am watching a documentary about the little auk.*]	J'ai nettoyé ma chambre avec le mergule. [*I cleaned my room with the little auk.*]
Mouffette [***Skunk***]	Pendant ma promenade en forêt, j'ai vu une mouffette. [*During my walk in the forest, I saw a skunk.*]	Elle se protège du soleil avec sa mouffette. [*She protects herself from the sun with her skunk.*]
Saïga [***Saiga***]	Je cours moins vite que le saïga. [*I run slower than the saiga.*]	Je suis allée à l'école en saïga. [*I went to school in saiga.*]
Caban [***Peacoat***]	J'ai bien chaud avec ce caban. [*I am warm in this peacoat.*]	Aujourd'hui j'ai joué au caban. [*Today I played to peacoat.*]
Cardigan [***Cardigan***]	Elle a acheté des chaussettes et un cardigan. [*She bought socks and a cardigan.*]	Il s'est blessé en touchant un cardigan. [*He hurt himself touching a cardigan.*]
Redingote [***Frock Coat***]	Il a troué sa redingote. [*He tore a hole in his frock coat.*]	Elle a ouvert la fenêtre en tirant la redingote. [*She opened the window by pulling the frock coat.*]
Sarrau [***Smock***]	Il y a plusieurs tâches sur ce sarrau. [*There are several stains on the smock.*]	Dans ma trousse il y a toujours un sarrau. [*The smock is always in my kit.*]
Anone [***Custard Apple***]	Elle a préparé un dessert à l'anone. [*She has prepared a custard apple dessert.*]	Il a mal à l'anone. [*His custard apple hurts.*]
Curuba [***Banana Passion Fruit***]	Il est allergique à la curuba. [*He's allergic to banana passion fruit.*]	Elle dort sur son curuba. [*She sleeps on her banana passion fruit.*]
Durian [***Durian***]	Il déguste un morceau de durian. [*He is enjoying a piece of durian.*]	Elle invite ses amis au durian. [*She invites her friends to the durian.*]
Sapote [***Sapote***]	J'ai goûté une compote de sapote. [*I tasted a compote of sapote.*]	Je coupais les ingrédients avec ma sapote. [*I cut the ingredients with my sapote.*]
Biniou [***Bagpipe***]	Il souffle de toutes ses forces dans le biniou. [*He blows the bagpipe with all his might.*]	C'est dangereux de nager sans son biniou. [*It is dangerous to swim without your bagpipe.*]
Bongo [***Bongo***]	Avec ses mains, il tape sur le bongo. [*With his hands, he taps on the bongo.*]	Sur sa fenêtre, elle a accroché un bongo. [*She has hung a bongo on her window.*]
Cithare [***Zither***]	Elle n'a jamais entendu le son de ma cithare. [*She's never heard the sound of my zither.*]	Elle éteint l'incendie avec une cithare. [*She puts out the fire with a zither.*]
Clavecin [***Harpsicord***]	Il prend des cours de clavecin. [*He takes harpsichord lessons.*]	Dans sa poche, il y a un clavecin. [*In his pocket is a harpsichord.*]

Appendix 10. Analyses for the Sentence Judgment Task Study 2

Descriptive Statistics from the Sentence Judgment Task by Learning Group

	Learning	Session	Mean	SD
Accuracy	Visual	IMMEDIATE	0.64	0.48
		DELAYED	0.63	0.48
	Oral	IMMEDIATE	0.65	0.48
		DELAYED	0.62	0.48

Model Info

Model Type	Logistic Model
Model	Accuracy ~ 1 + Learning + Session + Learning:Session + (1 | Participant) + (1 | Target)
Distribution	Binomial
Link function	Logit
Number of Trials	2944
Converged	yes
C.I. method	Wald

Model Results

Factor	X^2	df	p
Learning	0.00	1.00	.985
Session	0.73	1.00	.392
Learning ✻ Session	0.20	1.00	.655

Parameter Estimates (Fixed Coefficients)

Parameter	Estimate	SE	Exp(B)	Exp(B) 95% Confidence Intervals		z	p
				Lower	Upper		
(Intercept)	0.61	0.10	1.83	1.49	2.25	5.77	<.001
Learning	-0.00	0.15	1.00	0.74	1.34	-0.02	.985
Session	-0.07	0.08	0.93	0.79	1.10	-0.86	.392
Learning ✻ Session	-0.07	0.17	0.93	0.67	1.28	-0.45	.655

Random Components

Groups		Variance	SD	ICC
Participant	(Intercept)	0.35	0.59	0.10
Target	(Intercept)	0.08	0.29	0.03
Residual		3.29	1.81	