Beyond Vocabulary Size:

Depth of Vocabulary in Bilingual Children and the Role of Language Experience

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For my parents,

who taught me to reach for the stars

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Abstract

A strong vocabulary is necessary for academic learning but research shows that lexical performance is lower for bilingual children compared to monolingual peers when measuring their performance in each language separately. This has been shown for breadth of vocabulary, but few studies have looked at vocabulary depth. Vocabulary breadth measures how many words are known, while depth of vocabulary considers the degree of word knowledge and reflects the multi-dimensionality of the lexicon. The acquisition of depth requires another set of resources than breadth of vocabulary. Several large-scale studies show that many bilingual students struggle to keep up with monolingual peers in academic settings and limited vocabulary could be a contributing factor. Examining bilingual performance on depth of vocabulary would offer insights on supporting word learning for bilinguals and facilitating academic success. Amount of exposure has been shown to affect vocabulary breadth but only a handful of studies have examined vocabulary depth in relation to bilingual language experience. It is likely that the relationship between language experience and vocabulary depth will be discordant with that of vocabulary breadth. Yet this is not clearly understood and neither are the consequences for vocabulary learning and use in bilingual school-age children.

The focus of the present thesis was to examine depth of vocabulary in bilingual French-English school-age children and the effect of language experience, measured as language exposure and age of acquisition to each language. The thesis is organized into three studies, addressing this issue by tapping into different dimensions of word knowledge. Study 1 examined depth of semantic representations in third-graders with the task of formal word definitions, a multi-dimensional and academic task found to predict literacy skills. Study 2 focused on use of vocabulary knowledge in first and third-graders by employing the task of verbal fluency, word

generation under semantic and phonemic constraints. Finally, Study 3 examined the learning of new and complex vocabulary in an incidental word learning task in grade 3, specifically examining whether bilinguals were helped or hindered by bilingual input.

The findings revealed areas of strength in the bilingual children, in that, despite significantly smaller vocabulary breadth, they performed on par with the monolingual children on several tasks. Study 1 found no significant differences between groups on semantic content or linguistic form of word definitions, but lower performance for bilinguals on self-estimated knowledge (measuring degree of confidence). Study 2 found equal performance on phonemic fluency but not semantic fluency, where the bilinguals performed lower. Study 3 found that bilinguals and monolinguals performed on par on the word learning task under monolingual conditions, mimicking the real-life academic setting for these children. However, when bilingual children did the task in bilingual conditions, their performance appeared dependent on language exposure, in that only children with lower exposure (< 40%) were helped by bilingual input. An overall trend across studies was that amount of language exposure, either cumulative or current, appeared to not have as strong an influence on depth of vocabulary in contrast to what has been shown for vocabulary breadth. In several areas, a threshold effect of exposure appeared likely.

In conclusion, the studies emphasize that depth of vocabulary involves linguistic faculties or processes that help bilingual children overcome their smaller vocabulary size in the language in question. The present work suggests that, to help bilingual children compensate for a smaller L2 vocabulary, academic support could focus on multi-dimensional word learning strategies and building depth of vocabulary by tapping into areas of strength in bilinguals. The findings also show a nonlinear relationship with amount of language exposure and suggest that quantity and quality vary in importance at different points in lexical development.

Résumé

Un vocabulaire important s'impose pour maîtriser les apprentissages scolaires, mais les recherches démontrent que, en termes de performance lexicale, les enfants bilingues ont de moins bons résultats que ceux monolingues, et ce, dans leurs deux langues. Ceci a été largement démontré pour l'étendue du vocabulaire mais rares sont les études qui se sont penchées sur la profondeur du vocabulaire. L'étendue du vocabulaire évalue le nombre de mots connus, tandis que la profondeur du vocabulaire prend en compte le degré de connaissance lexicale et se réfère à la multi-dimensionnalité du lexique. L'acquisition de la profondeur nécessite une autre gamme de ressources que l'étendue du vocabulaire. Plusieurs études à grande échelle montrent que les étudiants bilingues ont des difficultés à se lier à leurs camarades monolingues dans les milieux académiques et cela pourrait en partie être imputable à leur vocabulaire limité. L'étude de la performance des jeunes bilingues en matière de profondeur du vocabulaire pourrait donc ouvrir de nouvelles perspectives d'étayage de leurs apprentissages lexicaux et ainsi favoriser leur réussite académique. Il existe de nombreuses études sur la profondeur du vocabulaire mais seules quelques-unes se sont penchées plus précisément sur le lien entre la profondeur du vocabulaire et l'expérience du langage bilingue. Il est probable que le lien entre l'expérience linguistique et la profondeur du vocabulaire ne soit pas comparable avec celui qui existe avec l'étendue du vocabulaire mais il n'y a pas de conclusions claires à ce sujet. De plus, les conséquences concernant l'apprentissage et l'usage du lexique pour les enfants bilingues en âge d'être scolarisés ne sont pas non plus bien définies.

Dans cette thèse, nous nous sommes attelés à étudier la profondeur du vocabulaire chez les enfants bilingues français-anglais en âge d'être scolarisés et les effets de leur expérience langagière, en évaluant leur exposition à la langue et l'âge auquel ils ont acquis chacune des

langues. La thèse est organisée autour de trois études, traitant de cette question en abordant différentes dimensions de la connaissance sémantique. Dans l'étude 1, nous avons évalué la profondeur des représentations sémantiques d'élèves de troisième année, en les faisant travailler sur des définitions de mots formels avec une tâche scolaire multidimensionnelle permettant d'estimer les capacités de lecture et d'écriture. L'étude 2 a mis l'accent sur l'usage des connaissances lexicales par les élèves de première et troisième année en utilisant une tâche mesurant la fluidité verbale et la génération de mots avec des contraintes sémantiques et phonémiques. Enfin, dans l'étude 3, nous avons étudié le processus d'acquisition d'un vocabulaire nouveau et complexe lors d'une tâche implicite d'apprentissage lexical donnée en troisième année, tout en observant si le bilinguisme des enfants a constitué une aide ou une entrave à l'apprentissage.

Les résultats de nos études ont révélé les domaines dans lesquels les enfants bilingues excellent. Bien que leur vocabulaire soit sensiblement plus pauvre, ils sont plus performants que les enfants monolingues dans plusieurs tâches. L'étude 1 n'a révélé aucune différence notable entre les deux groupes pour ce qui est des contenus sémantiques ou des formes linguistiques des définitions lexicales. En revanche, les bilingues ont été moins performants que les monolingues lorsqu'ils devaient évaluer le contenu de leur connaissance sémantique. L'étude 2 a révélé que les performances des monolingues et des bilingues étaient équivalentes en matière de fluidité phonémique, mais que ces derniers ont été moins performants pour la fluidité sémantique. Enfin, l'étude 3 a montré que les bilingues et les monolingues ont des résultats comparables pour la tâche d'apprentissage lexical dans des conditions monolingues, qui reproduisent la réalité de la vie de ces enfants en milieu scolaire. En revanche, lorsque les enfants bilingues ont exécuté la tâche dans des conditions bilingues, leur performance a varié selon leur exposition avec la

langue. Seuls les enfants avec une exposition plus faible (< 40%) ont été aidés par leur bilinguisme. De l'ensemble de ces études, il ressort une tendance générale : le degré d'exposition linguistique, soit cumulatif ou intensif, n'a visiblement pas eu beaucoup d'influence sur la profondeur du vocabulaire, contrairement à ce qui était ressorti des études concernant l'étendue du vocabulaire. Dans plusieurs domaines, l'effet de seuil d'exposition semble plus probant.

Pour conclure, les études soulignent le fait que la profondeur du vocabulaire met en jeu des facultés ou des processus qui aident les enfants bilingues à surmonter leurs manques de connaissances lexicales dans la langue en question. Cette thèse montre que pour aider les enfants bilingues à compenser leur vocabulaire moins riche (L2), le soutien scolaire pourrait s'appuyer sur des stratégies d'apprentissage linguistique multidimensionnelles et pourrait permettre de construire la profondeur du vocabulaire en exploitant des domaines dans lesquels les bilingues excellent. Les résultats montrent aussi un lien non linéaire avec le degré d'exposition à la langue et indiquent que l'importance de la quantité et de la qualité varient à différents stades du développement lexical.

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Preface and Contribution of Authors

The thesis presented here examined the mechanism of how bilingual school-age children reach depth in their vocabulary in relation to their language experience. The three studies report novel findings on bilingual performance on three tasks measuring depth of vocabulary, two of the tasks constructed specifically for this thesis, and examine the role of language experience, measured as amount of language exposure and age of acquisition. The work has theoretical implications for understanding the relationship between language experience and development of vocabulary depth in bilinguals as well as practical implications for how word learning in bilinguals can be supported in academic settings.

The work presented in this thesis is the work of me, Myrto Brandeker, conducted under the supervision of Dr. Elin Thordardottir, and the three manuscripts are co-authored by us both. The three studies were part of a larger research project conducted in Dr. Elin Thordardottir's laboratory and, as such, the design and recruitment of the larger project was conceptualized by Dr. Elin Thordardottir. However, the main premise of the three studies presented in this thesis were conceptualized and designed by me under Dr. Elin Thordardottir's supervision. For Study 1 and 3, I constructed two novel tasks. For Study 2, a task well-known in the literature was used but the premise behind including the task in this study was conceptualized by me. Further, I was responsible for data analysis for these three studies as well as manuscript writing. Editorial suggestions and comments were received from Dr. Elin Thordardottir, as well as committee members Dr. Laura Gonnerman and Dr. Roy Lyster. Preliminary findings from this thesis were presented at the American Speech-Language-Hearing Association Convention (ASHA; Chicago, IL, USA) in 2013 and the International Clinical Phonetics and Linguistics Association Conference (ICPLA; Halifax, NS, Canada) in 2016.

1. General Introduction

Words are an essential part of any language. Both the learning of new words and the use of known words represent the foundation of academic learning and success. Poor vocabulary knowledge limits the ability to utilize academic instruction and poor use of vocabulary hinders the advancement of spoken and written language. A large body of research has shown that the vocabulary of bilingual children is smaller compared to that of monolingual peers when looking at their first (L1) and second language (L2) separately, both in preschool (e.g., Hammer, Lawrence, & Miccio, 2008; Pearson, Fernández, & Oller, 1993) and school-aged children (e.g., Bialystok, Luk, Peets, & Yang, 2010; Oller, Pearson, & Cobo-Lewis, 2007). This causes concern for the academic outcomes of bilingual children. Large-scale comparisons of performance have shown that bilingual students struggle in L2 school settings (Donahue, Finnegan, Lutkus, Allen, & Campbell, 2001; OECD, 2010) and limited vocabulary skills might be a part of the problem. By knowing what factors affect the vocabulary development of bilingual school-age children, we will be able to offer focused support for word learning, which will, in turn, facilitate academic success. One factor that has been shown to have an impact on vocabulary development is amount of language exposure, found for both monolingual (e.g., Hart & Risley, 1995; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991) and bilingual children (e.g., Elin Thordardottir, 2011, in press; Hoff et al., 2012; Pearson, Fernandez, Lewedeg, & Oller, 1997). However, the studies on bilingual vocabulary development have largely focused on vocabulary breadth (i.e., the size of vocabulary – how many words that are known). There is more to vocabulary knowledge than being able to match a label to a concept. Knowing the full meaning of a word includes semantic features and relations, morpho-syntactic and pragmatic properties, as well as phonological and orthographical representations.

Research on depth of vocabulary in bilinguals is scarce compared to vocabulary breadth studies and only a handful of studies have examined vocabulary depth in relation to language experience. The scope of vocabulary depth is quite different than breadth and acquiring depth requires another set of resources, which is consistent with the hypothesis that the relationship between language experience and vocabulary depth will be discordant with that of vocabulary breadth. However, this is not clearly understood. Neither are the consequences that this might have for vocabulary learning and use in bilingual school-age children. The focus of the present thesis was to examine how bilingual school-age children reach depth in their vocabulary and to what extent their experience of each language influences different aspects of depth. This was done by employing tasks tapping into different dimensions of word knowledge.

1.1 Depth of Vocabulary

Depth of vocabulary knowledge measures to what degree a word is known, while breadth of vocabulary measures how many words are known. Accordingly, vocabulary breadth does not consider that words can be known to a greater or lesser extent, while the key assumption in vocabulary depth is that word knowledge can be seen as a continuum from not knowing a word to being able to describe it in detail and within several dimensions (Vermeer, 2001; but see discussion in Schmitt, 2014, for a different view). In their spoken form, words are a complex sequence of articulations and acoustic cues, while in their mental lexical entries, words are placed in semantic networks and linked to syntactic and morphological features, with both phonological and orthographical representations (Samuelson & McMurray, 2017). In its simplest form, a word can be considered along three dimensions: form, meaning, and use (Nation, 2001). In a more detailed account, a word can also be viewed within dimensions of themes, phonology, morphology, syntax, concepts, pragmatics, and socio-linguistic register (Ordonez, Carlo, Snow,

& McLaughlin, 2002; Vermeer, 2001). As well, words are placed in semantic networks, with nodes linking to all these dimensions. The richer the connections between nodes, the deeper the word knowledge (Vermeer, 2001). Bloom (2000) describes word knowledge as having both a certain mental representation or concept as well as an association with a linguistic form. Considering this multidimensionality of word knowledge, it is not surprising that the learning of words is complex and engages the interaction of several cognitive processes (Bloom, 2000; Macnamara, 1982). Word learning starts with an initial exposure of a new word and a segmentation of the speech stream to identify the word's phonological form and morpho-syntactic properties. This is followed by mapping that form to a concept by assigning meaning to the word. Finally, word learning involves a refinement of knowledge with additional exposure to the word in a variety of contexts (for a recent review on word learning see He & Arunachalam, 2017). While growth of vocabulary breadth is quick, the development of depth of vocabulary is slower, based on multiple exposures, and engages a wider range of processes (Bloom, 2000).

There are different ways to measure depth of vocabulary (Schmitt, 2014; Wesche & Paribakht, 1996), in part depending on the dimension you wish to focus on. Commonly, depth measures focus on defining words, giving functional characteristics or relations, or essential features (Vermeer, 2001). Looking at the form and meaning of words can be achieved by formal word definitions or by giving superordinates. The use of words can be examined by word generation based on hierarchical relations (word associations) or based on semantic or phonemic constraints (verbal fluency). Further, yet another aspect of vocabulary depth is looking at how learning of new words takes place.

1.1.1 Depth of vocabulary in bilingual children. While research on breadth of vocabulary has shown relatively consistent patterns of performance in bilingual children, most

often compared to their monolingual peers (e.g., Bialystok et al., 2010; Hammer et al., 2008; Oller et al., 2007), depth of vocabulary has been less studied. Our understanding of bilingual performance on depth measures is lacking, in part due to the various ways depth of vocabulary can be conceptualized and measured. The study of vocabulary depth is relevant as it predicts reading comprehension and, in turn, academic success, shown for bilingual students as for their monolingual counterparts (e.g., Proctor, Silverman, Harring, & Montecillo, 2012; Proctor, Uccelli, Dalton, & Snow, 2009). It is therefore of concern that the available evidence shows lower performance for bilingual students on measures of vocabulary depth (e.g., Schoonen & Verhallen, 2008; Verhallen & Schoonen, 1993; Vermeer, 2001). However, depending on the dimension measured, some studies also find similar performance between bilingual and monolingual children, as with word associations (Sheng, McGregor, & Marian, 2006) or some studies on verbal fluency (cf. Friesen, Luo, Luk, & Bialystok, 2015; Kormi-Nouri, Moradi, Moradi, Akbari-Zardkhaneh, & Zahedian, 2012). Research on vocabulary depth in bilingual children has revealed, as for monolingual children, an age effect with different patterns emerging in later grades compared to earlier grades (e.g., Kormi-Nouri et al., 2012; Schoonen & Verhallen, 2008). Other factors appear to play a role as well, in particular language experience variables, but the specificity of their contribution is largely unknown.

In a large-scale study, Vermeer (2001) contrasted breadth and depth of vocabulary in monolingual and bilingual children at the ages of four and seven years. The bilingual children spoke Dutch as their L2 and came from a variety of L1 backgrounds. The studies found higher performance for monolingual children on receptive and expressive measures of breadth as well as depth. However, the composition of the association networks on the depth task was similar across the participants. Further, Vermeer found that the probability of knowing a word was

dependent on the word's frequency in primary education. High-frequency words were more likely to be known by both bilingual and monolingual children. This dependency on input for performance might, at least in part, explain the lower performance for bilingual children, considering that they divide their daily language exposure between two (or more) languages, and thus get less input in each language.

1.2 The Effect of Language Experience on Vocabulary Development

Bilingual children form a heterogeneous population, inherently different on several factors which can potentially influence their language development, for example cultural and socioeconomic factors, cross-linguistic differences and similarities, and their experience of each language (see review in Pearson, 2007). In this thesis, the focus will be on language experience measured as amount of language exposure and age of acquisition to the language being measured, as these have been shown to influence vocabulary development.

1.2.1. Language exposure. Amount of language exposure in bilingual children has been shown to affect breadth of vocabulary across ages, both receptive and expressive, in a large body of research (e.g., Elin Thordardottir, 2011, in press; Hoff, Rumiche, Burridge, Ribot, & Welsh, 2014; Pearson et al., 1997; Pearson et al., 1993), but the patterns vary somewhat based on how exposure is measured. In a landmark study, Elin Thordardottir (2011) measured exposure cumulatively since birth by mapping the child's exposure patterns in a variety of contexts year-by-year in bilingual French-English five-year-olds. She found a strong and systematic relationship between amount of cumulative exposure and performance on receptive and expressive vocabulary size. Children with exposure lower than 40% performed below monolingual range in that language. In a recent follow-up study, Elin Thordardottir (in press)

found similar effects in school-age children where amount of cumulative exposure was a significant predictor for both receptive and expressive vocabulary size in grade 1 and grade 3.

Other studies have found an effect of exposure on vocabulary breadth by measuring current amount of exposure based on an average week (e.g., Hoff et al., 2012) or by, more coarsely, defining current exposure as a binary factor based on which of the languages is most dominantly spoken in the home (e.g., Dijkstra, Kuiken, Jorna, & Klinkenberg, 2016; Gathercole, Kennedy, & Thomas, 2015; Oller & Eilers, 2002). Few studies have included both cumulative and current exposure and there is no consensus in the literature as to the contribution of each type of exposure measure to vocabulary development, even though there is some recent evidence that there might be a dissociation between the two measures (Cohen, 2016).

Since word learning is dependent on the explicit exposure to words and considering that building depth of vocabulary knowledge requires multiple exposures, it is also relevant to examine the effect of exposure in different contexts on domain words, for example the effect of language exposure in educational settings on academic words. To our knowledge, this has not yet been examined in detail. Bialystok et al. (2010) showed that bilingual children were outperformed by monolingual peers on L2 receptive vocabulary on home domain words, but that performance was equal on school domain words, indicating that the context of your language exposure plays a significant role as well as the amount of exposure.

Very few studies have looked at depth of vocabulary in bilingual children in direct relation to language exposure. Vermeer (2001), discussed above, showed that frequency of words in daily input played a role in lexical performance of both bilingual and monolingual children. Hovsepian and Elin Thordardottir (2015) used language samples to examine vocabulary composition in bilingual three- and five-year-olds. They found that the bilingual children, even

those with very little exposure to the language in question, had a composition similar to age-matched monolingual peers and not monolingual children at a similar language level, which indicates that this dimension of vocabulary depth (composition of word classes used) is influenced by other factors than exposure such as world knowledge and age-appropriate interests. Further, Sheng, Bedore, Peña, and Fiestas (2013) examined word associations in Spanish-English bilingual children (age: 7-12 years) with different levels of exposure to the two languages. The focus was on comparing children with high and low exposure to either of the languages. Exposure was based on current language patterns during a typical weekday and a typical weekend day. Children with balanced exposure (45-55%) were excluded and remaining children were divided into age-matched high English exposure or high Spanish exposure groups. Results showed a main effect of age in that older children outperformed the younger children. Further, there was a relationship between depth of semantic knowledge and amount of current exposure. Groups with high language exposure showed higher performance on the word association task in that language. The study also saw a significant predictive effect of current language use for semantic performance. Thus, exposure plays a role in depth of vocabulary, however, the extent of the effect is unknown.

1.2.2 Age of acquisition. The effect of age of language acquisition (AoA) has been debated in the literature for decades. The timing of when one becomes bilingual has been one of the factors considered to matter most for L2 mastery (e.g., see review in Harley & Wang, 1997). The idea of a heightened sensitivity for language learning before a certain age was introduced by Lenneberg as the critical period hypothesis (1967). In its original form, this hypothesis argued that children have an innate mechanism to learn language that develops gradually from the second year of life and ceases at puberty, after which successful mastery is not possible (see

discussion in Colombo, 1982). The most robust findings for age effects in language learning have been seen in L2 pronunciation (see Harley & Wang, 1997), while the findings on the lexical domain are mixed. Support for a critical period for lexical attainment comes, among others, from Abrahamsson and Hyltenstam (2009) who investigated the ability to achieve native-likeness on a wide range of in-depth linguistic tasks in a large group of L2 adult learners of Swedish with Spanish as their L1. Their participants were defined as early or late learners of Swedish with a cut-off set at acquisition before or after age 12. The early learner group had a mean age of 28 years and the late learner group had a mean age of 41 years. Few of the late learners were perceived as native-like, while most of the early learners were perceived as native speakers of Swedish. However, even participants perceived as native-like showed subtle differences when their semantic performance was scrutinized. Following this study, Granena and Long (2013) examined age effects for the lexical domain (along with phonology and morphosyntax) for Chinese learners of Spanish, and found a negative correlation between lexical tasks and AoA, starting at the age range 7-15 years of language onset.

Other studies have found evidence against age effects in the lexical domain. Lahmann, Steinkrauss, and Schmid (2015) looked at long-term L2 attainment by measuring grammatical and lexical complexity in spontaneous speech. They found that AoA was not a significant factor for L2 performance in older adults with AoA ranging from 7-17 years. Further, Hellman (2011) examined vocabulary size and depth of knowledge in late learners of English (L1 = Hungarian, AoA after the age of 16) and compared to the performance of monolingual English speakers and bilingual early learners. While there were no group differences between early bilinguals and monolinguals, late bilinguals were outperformed by both groups on an auditory receptive vocabulary task. However, they reached native levels on a written vocabulary task and a word

association task, suggesting that native-like levels of vocabulary knowledge are attainable even for late L2 learners.

Consequently, it is important to take AoA into account when studying bilingual language development. Bilingual children are typically categorized into one of two groups depending on when their L2 acquisition started. In general, simultaneous or early bilingualism refers to children learning both their languages at the same time from the beginning. Sequential or late bilingualism refers to learning a second language after the first language is already in place. The conventional and most-often used cut-off is three years of age, according to a definition first set by McLaughlin (1978). In school-aged bilinguals, two recent studies have directly compared the L2 performance of simultaneous and sequential children in the areas of vocabulary and grammar, controlling both AoA and overall amount of exposure to the two languages (Elin Thordardottir, in press; Unsworth, 2016). Both studies found simultaneous and sequential bilinguals to perform comparably, and thus call into question the traditional distinction between these two groups. Further, a recent study of L2 learners of Icelandic similarly found no effect of AoA starting early or late in the preschool years (Elin Thordardottir, submitted).

1.3 The Bilingual Context of Montreal

The present thesis was conducted in Montreal, Quebec, which offers a bilingual context where French and English are considered to be majority languages. Even though French is the predominant language, both languages are used throughout the community on an everyday basis. Montreal has a large immigrant population and many children grow up with a language other than French or English at home (31.9%; Statistics Canada, 2012). Official language policies in the province of Quebec state that children of immigrant parents must be schooled in French (Quebec, 1977). English is introduced as a second language to all children in the first grade with

one to two hours of instruction per week. This means that most school-aged children are bilingual to various degrees and very few are strictly exposed to only one language. However, this does not necessarily imply that all the children are functionally bilingual, but, rather, that they are spread out on a continuum of bilingualism and language experience. The unique language context of Montreal offers the possibility to study children all along this continuum, children who are simultaneous or sequential, with a large variability of language exposure (see previous studies by Elin Thordardottir, 2011, 2015, in press).

1.4 Overview of Thesis

The main objective of the present work was to examine depth of vocabulary in bilingual school-age children and the extent to which their performance was affected by experience in each language, measured as different types of language exposure and early versus late AoA. The findings increase our understanding not only of the depth of vocabulary in bilinguals but also of the complex relationship between language experience and vocabulary beyond the scope of breadth in a population that divides their daily language input between two languages. The thesis is organized into three studies that address different aspects of vocabulary depth. Study 1 examines depth of semantic representations with the task of formal word definitions, a multi-dimensional and academic task found to predict literacy skills. Study 2 focuses on use of vocabulary knowledge with the task of verbal fluency, word generation under semantic and phonemic constraints. Study 3 looks at learning of new and complex vocabulary in an incidental word learning experiment, specifically examining whether bilinguals are helped or hindered by bilingual input in academic word learning, and how this might be affected by amounts of language exposure. Together, the studies span both academic and non-academic skills and will

show what might contribute to how bilingual school-age children reach depth in their vocabularies and to what extent this is dependent on language experience factors.

2. General Methods

2.1 Participants

The work presented here was part of a larger project being conducted in Elin Thordardottir's laboratory (see initial publication in Elin Thordardottir, in press). Over the span of four years (2012-2016), over 130 children were recruited for participation and tested within the larger project. All children were enrolled in French-curriculum schools and were attending either grade 1 or 3. Selection of participants in the studies presented here was based on completion of the tasks specific to each of the studies. Since not all children completed all tasks, the number of participants varies somewhat across the three studies. Moreover, Study 1 and 3 include only children from grade 3 since the tasks employed were academically advanced and grade-specific. For Study 2, the main task of verbal fluency is appropriate across ages and it was therefore decided to include verbal fluency in the test protocol for grade 1 to enable a comparison across grades. Details on recruitment and participant characteristics are described in each manuscript.

2.2 Procedure

The participants were seen within the frame of the larger research project conducted in Montreal, Quebec, Canada, and the tasks exclusive to the current thesis were part of a larger test protocol. The bilingual children were seen twice, with one session in French and one in English, and each session taking around 1.5-2 hours. Details on the procedure for each of the three studies are described in the respective manuscripts.

2.3 Ethics Approval

This research project was approved and overseen by the Institutional Review Board of the Faculty of Medicine of McGill University. The parents of the participants signed an informed consent form.

3. Manuscript 1

Depth of Vocabulary Knowledge in Bilingual Children:
Word Definitions and the Effect of Language Experience

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Abstract

Vocabulary is crucial to academic learning and success but lexical development is also an area of concern for bilingual children. Research on vocabulary breadth has shown lower performance in each language compared to monolingual peers. However, few studies have looked at vocabulary depth. Examining different aspects of vocabulary depth enables an identification of strengths and weaknesses in bilingual children, which in turn increases our understanding of how academic vocabulary development in bilinguals can be supported. The purpose of the present study was to examine bilingual and monolingual children's ability to create formal definitions, in relation to their language experience. Word definitions is an advanced academic skill which taps into several dimensions of word knowledge, both linguistic and meta-linguistic. Bilingual French-English speaking third-graders and monolingual peers participated ($N = 50$). All children were enrolled in French-curriculum schools. The children's language exposure was carefully mapped in regards to cumulative and current language exposure, as well as exposure patterns at home and at school. A word definitions task based on grade-appropriate words from everyday life, math, and science was used. The bilingual children were tested in both French and English. The results show that, despite lower performance on vocabulary breadth, the bilingual children achieved similar performance as monolingual peers on semantic content and linguistic form, indicating the involvement of other language faculties or processes. Further, there were no significant correlations with cumulative and current exposure measures in French, whereas the opposite was true for English, implying that a threshold effect had been reached in French.

Bilingual children have been found to lag behind monolingual peers in their lexical development when looking at each language separately (e.g., Hammer, Lawrence, & Miccio, 2008; Oller, Pearson, & Cobo-Lewis, 2007), a particularly troublesome weakness since vocabulary is vital to academic success and a strong predictor of reading ability (e.g., Kieffer & Lesaux, 2012; Proctor, Carlo, August, & Snow, 2005). The study of how to strengthen the second language (L2) lexicon of bilingual children is therefore an area of urgency and begins with identifying strengths and weaknesses of typical bilingual development. In the literature, there is now a consensus that a significant portion of bilingual children have smaller vocabulary sizes in each of their languages compared to those of monolingual peers, as seen in both preschool (e.g., Hammer et al., 2008; Pearson, Fernández, & Oller, 1993) and school-age populations (e.g., Bialystok, Luk, Peets, & Yang, 2010; Oller et al., 2007). However, in contrast to these measures of breadth, our knowledge is limited when it comes to depth of vocabulary in bilingual children, for example on word definitions. The ability to create word definitions is an important academic skill, proven to predict literacy (Snow, Cancini, Gonzalez, & Shriberg, 1989). The available evidence leans toward bilingual children performing lower than monolingual peers (e.g., Verhallen & Schoonen, 1993) but performance also appears dependent on grade level, with children in later grades narrowing the gap as seen in a large-scale study on bilinguals from a variety of language backgrounds (Schoonen & Verhallen, 2008). The answer to why the gap is smaller in later grades could inform the question as to how bilingual children reach their depth of vocabulary, and reveal insights on how we can support bilingual children in their deep word knowledge, thereby facilitating their academic success. One of the factors proven to affect bilingual lexical development is language exposure, as many studies have shown for vocabulary breadth (e.g., Elin Thordardottir, 2011; Pearson, Fernandez, Lewedeg, & Oller,

1997; Pearson et al., 1993). However, it is not clear to what extent language exposure affects depth of vocabulary. Considering that research also shows that many bilingual children are struggling in L2 academic settings (Donahue, Finnegan, Lutkus, Allen, & Campbell, 2001; OECD, 2010), it is pertinent to examine how words are being learned and how deep the word knowledge of bilingual children is. Going beyond mere vocabulary size and examining other dimensions of vocabulary knowledge will reveal new insights about how bilingual children achieve their depth of vocabulary and what factors contribute. The present study examined deep vocabulary knowledge in bilingual third-graders in comparison to their monolingual peers on a task of word definitions. Further, we also examined whether different types of language exposure vary in their effect on word definition performance to better understand to what degree the effect of language exposure is dependent on context, and thus narrow in on how bilingual children reach their depth of vocabulary.

Depth of Vocabulary Knowledge

The lexicon is a crucial part of language and there are different ways to measure lexical development. A common measure is to estimate how many words a child knows, known as the breadth of vocabulary. In contrast, looking at the depth of vocabulary estimates how much a child knows about a word. Vocabulary knowledge is a multi-dimensional construct and in its simplest form it can be said to include three dimensions: form (both oral and written), meaning, and use (Nation, 2001). The depth, or, differently put, the quality, of knowledge of every word in our lexicon varies along these three dimensions. Knowledge thus refers not only to semantic meaning, but also to knowledge about morpho-syntactic properties and use of pragmatic features, among others. Deep, high quality knowledge needs to include well-specified representations of form (both phonological and orthographic) as well as flexible representations of meaning

(Perfetti, 2007). According to Perfetti's lexical quality hypothesis (2007), high quality word knowledge implicates a fuller range of semantic dimensions, allowing for clearer discrimination among related words, while low quality knowledge is more context-bound and limits the discrimination of words in the same semantic field. There is little consensus in the research literature on the most appropriate way to assess depth of vocabulary although several different methodologies have been used. It is suggested that this lack of standardized measures might be caused by the complexity and multi-dimensionality of depth of vocabulary as well as the absence of a well-formed theoretical definition (see discussion in Li & Kirby, 2015). For the purposes of the current study, the ability to define words was chosen as the measure of lexical depth due to its multidimensional and meta-linguistic nature.

Word definitions. The ability to define words has been shown to predict literacy skills and has been used extensively in vocabulary training (e.g., Snow et al., 1989) as well as in both comprehensive language measures and intelligence tests. The task requires detailed knowledge about phonological representations, morpho-syntactic structure, semantic representations, pragmatic rules, and sociolinguistic register, as well as the ability to adhere to conventional linguistic form (Ordonez, Carlo, Snow, & McLaughlin, 2002). It is therefore a meta-linguistic task (Watson, 1985) and has been shown to be predicted by syntactic, phonological and lexical awareness (Benelli, Belacchi, Gini, & Lucangeli, 2006). Further, the ability to formally define words is correlated to vocabulary breadth (Ouellette, 2006). Word definition is considered to be highly relevant for professional academic writing and is viewed as one of the major academic language functions (Dalton-Puffer, 2007). Young children start off by creating concrete definitions of words, followed by functional definitions as they get older, and then move to conceptual definitions (Al-Issa, 1969). With increasing age, children start including

superordinates and giving definitions of more elaborate structures (Watson, 1985). It has been shown that the ability to define words continues to develop in young adulthood, emphasizing the complexity of the task (Nippold, Hegel, Sohlberg, & Schwarz, 1999).

In its most basic form, the task of word definitions asks the child to "Tell me about X", with or without further prompting (Watson, 1985). The target words used have been common nouns or verbs, or more abstract words. The expected response is commonly modeled in the Aristotelian style of formal definitions (Nippold et al., 1999). An Aristotelian definition takes the form "X is a Y that Z", where X is the term to be defined, Y is its superordinate category, and Z is one or more specifying features. These specifying features can be descriptive, comparative, functional, historical, or any combination of these (Dalton-Puffer, 2007). On the linguistic level, a formal definition contains the copula construction as well as adjectives and relative constructions (Dalton-Puffer, 2007). Thus, the ability to give a formal definition involves both linguistic and meta-linguistic knowledge. Importantly, definitions can lack the formal requirements of linguistic and meta-linguistic elements, but still be communicated adequately and contain relevant semantic information.

Depth of vocabulary knowledge in bilingual children. Studies focusing on breadth versus depth of vocabulary knowledge look at lexical development from different (yet equally important) perspectives. When it comes to vocabulary breadth in bilingual children, there is strong evidence in the literature that bilingual children have smaller vocabularies compared to monolingual peers when looking at each of their languages separately (e.g., Oller et al., 2007). One explanation for the smaller vocabulary size is the distribution of exposure between the two languages and the restriction this implies for the input of words in each language. A strong and systematic relationship has been found between vocabulary size and amount of language

exposure in that language, both in preschool (Elin Thordardottir, 2011) and school-age children (Elin Thordardottir, in press). When it comes to depth of vocabulary knowledge, the studies on bilingual children are limited and it is not established how the performance of bilingual children compares to that of monolingual peers.

Verhallen and Schoonen (1993) found that bilingual Dutch-Turkish speaking children showed less extensive and less varied meanings than monolingual Dutch speaking children on a task of extended word definitions in Dutch. The participants came from backgrounds with lower socio-economic status (SES) and were aged 9-11 years. In a later study, Schoonen and Verhallen (2008) confirmed lower bilingual performance when comparing monolingual and bilingual children in third and fifth grade in a large cross-sectional study of word associations. The bilingual children had a variety of first languages (L1) and were learning Dutch as their L2. However, the difference between groups was smaller in grade 5 than in grade 3. This narrowing of the gap is suggested by the authors to be attributed to a later paradigmatic shift in semantic organization for bilingual children. Although we currently lack evidence to either support or disprove this proposition, another perspective is that children in grade 5 have had two more years of L2 exposure in school and are therefore catching up to their monolingual peers.

Furthermore, Kieffer and Lesaux (2012) examined deep word knowledge with a multi-dimensional approach in sixth-graders learning English as L1 or L2 in a large-scale study. The bilingual students came from a variety of linguistic backgrounds. The authors summarized 13 deep vocabulary measures into three main dimensions by using confirmatory factor analysis: breadth, contextual sensitivity, and morphological awareness. The bilingual students scored significantly lower than the monolinguals across the three dimensions as well as on all individual tasks. However, the magnitude of differences was smaller than expected, from one-third to one-

half of a standard deviation below the monolingual group. All students came from similar, lower, SES backgrounds. Kieffer and Lesaux (2012) argue that, when it comes to depth of vocabulary knowledge, there might be other factors involved that decrease the gap compared to monolinguals, or even create an advantage, compared to studies on vocabulary breadth. The cognitive and linguistic consequences of bilingualism could, for example, enhance the knowledge about how words work or how to make use of contextual support, even when faced with limited vocabulary breadth. In the Kieffer and Lesaux study, the children's language exposure was not considered. It is also plausible that the smaller differences could be due to longer schooling.

The Effect of Language Exposure on Lexical Development

It is well-known that monolingual lexical development is affected by richness of input (Hart & Risley, 1995; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). Similarly, the lexical development in each of the languages of bilingual children has been shown to be affected by their language exposure in each language (Elin Thordardottir, 2011; Hoff, Rumiche, Burridge, Ribot, & Welsh, 2014; Pearson et al., 1997; Pearson et al., 1993). However, these studies have mainly focused on the breadth of vocabulary and vary on how exposure was measured. Elin Thordardottir (2011) examined the effect of amount of language exposure on receptive and expressive vocabulary size in detail by measuring exposure to each language since birth in the child's regular daily environments such as home and daycare. The French-English bilingual five-year-olds were then placed on a continuum of how much exposure they had had to each language. The results showed a strong and systematic relationship between amount of exposure and both receptive and expressive vocabulary size in that language. The bilingual children who had had more than 40-60% cumulative language exposure since birth performed at equal levels

with monolingual peers. Similar results have since been found in bilingual toddlers, where a level of 40% exposure to that language ensured a level on par with monolingual peers on expressive vocabulary size (Hoff et al., 2012). Despite similar results, these two studies on young bilinguals measured exposure differently; Hoff et al. based exposure on a current average week and Elin Thordardottir on cumulative amount since birth.

When children enter school, the proportion of exposure in each language often changes (Bridges & Hoff, 2014; Hoff et al., 2014). They spend more time than before in an L2 setting (i.e., school) and, furthermore, it has been shown that many parents start speaking more L2 to their children after they start attending L2 school (Bridges & Hoff, 2014). This change in language exposure occurs at the same time as academic vocabulary learning begins. Elin Thordardottir (in press) examined the expressive and receptive vocabulary size of bilingual first- and third-graders, in relation to their cumulative language exposure since birth. She found that the French and English-speaking bilingual children performed lower than their monolingual peers on both measures. This was true for both grade 1 and 3, and irrespective of whether the bilingual children had begun their exposure to French early or late (set as before or after the age of 3 years). Further, cumulative language exposure was a significant predictor of both expressive and receptive vocabulary size. The findings reflect those on younger children (cf. Elin Thordardottir, 2011; Hoff et al., 2012).

Several studies have used current amount of exposure as a measure instead of cumulative amount or a proxy for current amounts of exposure such as the language most dominantly spoken in the home for a measure of L1 exposure and have found a relationship with vocabulary development (Dijkstra, Kuiken, Jorna, & Klinkenberg, 2016; Gathercole, Kennedy, & Thomas, 2015; Oller & Eilers, 2002), but few studies have directly compared the effect of cumulative

exposure to that of current exposure. Cohen (2016) showed that there is reason to examine any dissociation between the two exposure measures. She used both current and cumulative exposure measures in each language to examine the relationship between amount of exposure and receptive vocabulary size in bilingual French-English children (age: 6-8 years). All children attended a bilingual school where the majority of instruction was conducted in French but the children also had additional lessons in English. Cumulative and current exposure were found to correlate with receptive vocabulary size in that language, however, cumulative exposure was more strongly related to French, the main school language, and current exposure was correlated more strongly to English. This finding indicates dissociative effects of cumulative and current exposure, but could also be related to context-dependent effects of language exposure, that is, exposure at home compared to that at school. Additionally, studies have confirmed that home versus school exposure has an effect on the words a person knows. For example, a large study by Bialystok et al. (2010) divided the words on the receptive vocabulary size task into home and school domains. Their participants (age: 3-10 years) were all enrolled in English daycares or schools and the bilingual children had a variety of L1s in the home. The bilingual children were outperformed by the monolingual group on the total performance as well as on the home domain words. However, on school domain words, there was no significant difference between groups. If we assume that the bilingual children had more exposure to L1 than English at home (which is probable, but not measured directly), these findings show how the context of input has an explicit effect on the words that you learn.

Another language experience factor that has been debated in the literature is age of language acquisition (AoA), for decades considered to be one of the factors to matter most for L2 mastery (e.g., see review in Harley & Wang, 1997). But findings are mixed with regards to

lexical attainment with both support for (e.g., Abrahamsson & Hyltenstam, 2009) and against (e.g., Hellman, 2011) age effects. Bilingual children are typically categorized into one of two groups depending on when their L2 acquisition started. Simultaneous or early bilingualism refers to children learning both their languages at the same time from the beginning. Sequential or late bilingualism refers to learning a second language after the first language is already in place. The conventional and most-often used cut-off is three years of age, according to a definition first set by McLaughlin (1978), though other cut-offs have also been used in the literature (cf. Elin Thordardottir, 2011). However, disentangling AoA from cumulative amounts of language exposure is inherently challenging. Two recent studies that compared effects of AoA and cumulative exposure on vocabulary of bilingual children found few differences between simultaneous and sequential learners (Elin Thordardottir, in press; Unsworth, 2016), emphasizing that exposure amount has a greater impact than timing.

Taken together, the studies on the effect of language exposure show a strong relationship with both receptive and expressive vocabulary breadth. However, the effect on depth of vocabulary knowledge is unknown. At the time of writing of this paper we could find only two previous studies relating depth of vocabulary in bilingual children to amount of bilingual exposure. Hovsepian and Elin Thordardottir (2015) used language samples to examine vocabulary composition in bilingual three- and five-year-olds. They found that the bilingual children, even those with very little exposure to the language in question, had a composition similar to age-matched monolingual peers and not monolingual children at a similar language level, which indicates an effect of factors other than input, such as world knowledge and age-appropriate interests. Further, a study by Sheng, Bedore, Peña, and Fiestas (2013) examined word associations in school-aged bilingual children with higher current exposure to either

English or Spanish. They found a direct relationship between performance and amount of current exposure as well as a significant predictive effect of exposure.

We have been unable to find any study looking at word definitions directly in relation to bilingual exposure. Considering the multi-dimensionality and complexity of word definitions, it is plausible that the relationship between the ability to define words and language exposure is different in nature than the relationship between exposure and vocabulary breadth. Further, as the ability to form word definitions is an academic skill, the examination of language exposure at school and home separately will show any dependence on context for the effect of language exposure. It will help to answer the question of what contributes to the depth of vocabulary in bilingual school-aged children.

Aims of the Current Study

The main objective of the current study was to examine the depth of vocabulary knowledge in bilingual school-aged children in the context of their language exposure, and in comparison with monolingual peers. The purpose was to focus on children in third grade since their enrollment in L2 education for four years has given them ample exposure to L2 at the same time as being at a stage where the curriculum requires a sophisticated level of academic vocabulary. It was hypothesized that the bilingual children would perform lower than their monolingual peers based on previous findings (cf. Verhallen & Schoonen, 1993). However, due to the scarcity of studies on word definitions in bilinguals compared to monolinguals we were unable to predict the magnitude of the difference. Further, we aimed to examine the effect of language exposure on word definitions, and specifically whether any dissociation could be seen between the effect of cumulative and current exposure as well as home and school exposure. We predicted a relationship between language exposure and word definitions, especially language

exposure in school. Moreover, it was expected that the bilingual children would have a higher knowledge of the science and math words in French than English, due to their exposure in school to these academic words.

Specifically, the research questions were as follows:

1. How does bilingual performance compare to that of monolingual peers on a task of word definitions in third grade?
2. To what extent is deep word knowledge, measured as the ability to define words with regards to semantic content as well as linguistic form, dependent on amount of language exposure and age of acquisition?

Method

Participants

The participating children ($N = 50$) were enrolled in grade 3 in French schools in Montreal at the time of testing (mean age: 8 years 10 months; mean age in months = 106.42, $SD = 5.31$) and were recruited as part of a larger study conducted in the second author's research laboratory. The aim was to recruit both simultaneous and sequential learners of French, with a variety of amount of language exposure to French. Based on their age of acquisition to French and using a cut-off set at 36 months (cf. McLaughlin, 1978), the participants were divided into three groups: simultaneous learners of French (Bil-Sim; $n = 24$), sequential learners of French (Bil-Seq; $n = 12$), and monolingual speakers of French (Mon; $n = 14$). To be judged as monolingual for the purposes of this study, the children needed to have no other language than French at home, to have had very limited exposure to English at school (less than 5% cumulative exposure to English since birth) and be deemed functionally monolingual by their parents (i.e., not able to participate in any level of testing in a language other than French). Descriptive data of

the children's age of acquisition to French and English, as well as levels of language exposure can be seen in Table 1.

By Quebec law, all instruction in French schools must be in French. Two of the participants went to schools where the curriculum was exclusively taught in French, but where the children also had extra hours in Greek or Armenian, respectively, for activities outside the core curriculum. Further, some parents reported that their children were exposed to some English also in the after-school services provided by the school, leading to a variation in language exposure to French at school, despite enrollment in French-curriculum school. An analysis of language exposure in the home showed that 12 of the bilingual children had no exposure to French at home, while 24 of them had at least some French at home. A minority of the children were also exposed to a third language (n = 17, $\bar{x}$ = .30, SD = .25) or even a fourth language (n = 5, $\bar{x}$ = .04, SD = .02).

As per parent report, all but two of the children had typical language and general development without neuropsychiatric delays. Parents of two children reported medicated ADHD but the children were included in this sample as they participated well in testing and scored within normal range on the non-verbal brief IQ screening (a task requiring focus and attention for a larger length of time). Hearing was screened with a portable audiometer in the first session (20dB HL at 1, 2, and 4 kHz – a response at 0.5 kHz could not always be obtained due to ambient noise) and non-verbal IQ was assessed with the brief scale of Leiter-R (Roid & Miller, 1997). A one-way independent ANOVA between Bil-Sim, Bil-Seq, and Mon groups showed no significant differences in age, maternal education, or non-verbal IQ as measured by Leiter-R (see Table 2 for descriptive data and test statistics).

Procedure

Participants were recruited mainly from public and private schools by distributing letters informing all parents with children in third grade about the study, after obtaining written permission from the principal or school board. Parents registered their interest by either mail, telephone, or email. They were then contacted by a bilingual research assistant to ascertain eligibility, before receiving a consent form detailing the study and their participation. Children were also recruited via summer camps, after-school activities, and public postings, with the same recruitment procedure as that of schools.

Based on parent interview, the children were seen in one or two sessions, depending on their bilingual functionality. English and French were tested in separate sessions and with separate examiners. If the child was judged to not possess minimal proficiency in English, only French was assessed. Similarly, if the child was judged to have at least a low level of ability in English, that language was tested as well. The order of language tested was counterbalanced across the groups. All bilingual children completed testing in French, but three of the children deemed to be able to be tested in English did not complete testing in that language as their parents could not be reached for the scheduling of the second session. Testing took place at the research laboratory or at one of several testing locations across the greater area of Montreal, at the convenience of the families. All testing locations were in closed and quiet rooms where the child was alone with the examiner, and sometimes the parent at the parent's initiative. As the current study was part of a larger test protocol, the sessions took 1.5-2 hours, with one or two breaks in between. The order of tasks within each session was not set but dependent in part on children's attention levels and interest. All sessions were video-recorded for later analyses and transcribing.

Measures

Background measures. Parents were asked to fill in a detailed background questionnaire answering questions on the child's general and language development, as well as how much time the child had been exposed to each language across different environments (e.g., home, daycare, school) since birth. This questionnaire has been used extensively in previous studies (see Elin Thordardottir, 2011; Elin Thordardottir, Rothenberg, Rivard, & Naves, 2006). The parents also filled in a language activity diary, describing what languages the child listened to or spoke in an average school week for all the awake hours of each day. This diary was developed by the second author and is currently being used and evaluated. The background questionnaires were collected for all children. However, the language activity diaries for four of the children were not received despite repeated efforts to retrieve them. If anything was unclear in the parent report, clarification was sought either by telephone or personal conversation.

Based on the parent report, several language experience measures were calculated:

1. Cumulative amount of exposure total over lifetime, across various environments (to each language to which the child had been exposed)
2. Cumulative amount of exposure at home over lifetime (to each language to which the child had been exposed)
3. Cumulative amount of exposure at school since start of Kindergarten (to English and French; four years in total)
4. Current amount of exposure based on language activity diary (to each to which the child had been exposed)
5. Age of language acquisition to each of the languages to which the child had been exposed

Proficiency measures. Receptive vocabulary size was measured with Échelle de vocabulaire en images Peabody (EVIP - the Quebec French equivalent of the Peabody Picture Vocabulary Test; Dunn & Theriault-Whalen, 1993) in French and the Peabody Picture Vocabulary Test-III (PPVT; Dunn & Dunn, 1997) in English. Expressive vocabulary size was measured with the subscale Expressive Vocabulary from the standardized Quebec French Évaluation clinique des notions langagières fondamentales (Semel, Wiig, Secord, Boulianne, & Labelle, 2009) and its English equivalent Clinical Evaluation of Language Fundamentals-Fourth Edition (CELF-4; Semel, Wiig, & Secord, 2003). For the receptive and expressive tasks, only raw scores were used, due to the bias of using norms based on monolingual populations. As the present study is part of a larger project, the results of the receptive and expressive vocabulary size tasks for a larger sample are reported in Elin Thordardottir (submitted).

Word definition task. A word definitions task was constructed for this study and consisted of 24 items, mixing everyday words with academic words from grade-appropriate textbooks in math (Small, 2004) and science (Pelland, Brousseau, & Fortin, 2007; Pelland, Brousseau, Fortin, & Leroux, 2007). The textbooks were recommended for the official curriculum for grade 3 by the Ministry of Education of Quebec but were not necessarily used in all of the schools. However, all of the target words were expected to be included in any curriculum as they belonged to the academic vocabulary for that grade (for math or science words) or expected to occur in everyday life both in school and in society (for everyday words). Within each of the three subject categories (everyday, math, and science), there were four easier words and four more difficult words. The textbook words were chosen with the purpose of evaluating children's semantic knowledge of words they are expected to have learned by attending school. The specific aim of the task was to examine if the children could define words

well enough that it could be assumed that they had learned them. Everyday words, both easier as well as more abstract and/or less frequent words, were included to serve as controls for the textbook words. Note that all of the words in this task were difficult and their definitions were not expected to be easy for any of the children. However, all words were included in the curricula for grade three, and most of them appear in earlier grades as well. Further, almost all items are cognates, a consequence of the similarities between academic terminology in the two languages. Apart from semantic content, the task also measured the ability to adhere to conventional, linguistic form and self-estimated knowledge. The target words are specified below (French translation in parentheses):

- Demonstration items with the possibility of giving feedback (2 items)
    - Dog (un chien), ice cream (de la crème glacée)
- Everyday (8 items)
    - Easier: statue (une statue), audience (une audience), hero (un héro), calendar (un calendrier)
    - More difficult: authentic (authentique), election (une élection), diversity (la diversité), discrimination (la discrimination)
- Math (8 items)
    - Easier: graph (un graphique), symmetry (la symétrie), probability (la probabilité), cube (un cube)
    - More difficult: trapezoid (un trapézoïde), cumulative (cumulative), outcome (un résultat), denominator (le dénominateur)
- Science (8 items)

- Easier: mammal (un mammifère), gravity (la gravité), vaporization (la vaporisation), reptile (un reptile)
- More difficult: carnivore (un carnivore), density (la densité), buoyancy (la flottabilité), undulation (l'ondulation)

The child was first asked: "Do you know what ____ is?", in order to examine their self-estimated knowledge. To elicit a free definition, they were then asked: "What is ___?" and further prompted by: "Tell me more about ___?". The children were given no feedback to indicate if their answers were correct or incorrect. The items were presented according to difficulty, that is, a block of randomized easier items was followed by a block of randomized more difficult items. The task took approximately 10-20 minutes to complete. For a complete version of the word definitions task in English, see Appendix A.

Data Scoring and Reliability

The word definition task was scored by the first author on three variables: semantic content (max point two per item, 48 points in total), self-estimated knowledge (max point one per item, 24 points in total), and ability to construct formal definitions (max point two per item, 48 points in total). Semantic content was scored according to a pre-set scoring scheme with minimally required content, based on formal definitions found in both child and adult dictionaries. For example, to get partial credit for defining the word cube, children needed to mention that it is a shape. To get full credit, children also needed to mention that it is a 3-D shape with six equal sides (or give a similar explanation). Self-estimated knowledge was measured by asking children if they knew the word and scored with zero points (no) or one point (yes). Linguistic form was scored according to methods described in a review by Nippold (1995) and adapted for the purpose of this study. Children received zero points if a relevant form was

lacking and one point if they provided a superordinate category or if they related to a specific (and relevant) situation when appropriate. Another point was awarded if children also mentioned one or more characteristics that differentiated the word. For example, if children defined reptile as an animal that has scales and is cold-blooded, they received one point for giving the superordinate category as well as one point for giving characteristics. After testing was completed, it became clear that two of the target items in the word definition tasks were not equivalent in difficulty in English and French. The target word 'outcome' (French: un résultat) was more easily attributed to a test result in French than in English, which is something that almost all children are familiar with, while outcome is not as frequently used in the classroom. Similarly, the target word buoyancy (French: la flottabilité) was more easily derived from the everyday verb for floating (French: flotter), and was thus more easily defined even if the word itself was unknown to the children. These two targets were therefore removed. Further, to be able to compare scales of the three variables, the scoring of self-estimated knowledge was transformed by multiplying with 2 so that the scale of all three variables was 0-44 points. Hence, since the three subject areas (everyday, math, science) ended up with unequal numbers of items (8, 7, and 7, respectively), the analyses on the subject words were done on an average score per subject rather than total points.

Reliability was calculated by rescoring 20% of the data for both French and English. The rescoring was done by a trained research assistant, using the scoring schemes described above. Inter-rater reliability for French was high (semantic content: $r = .96$, $p < .001$; self-estimated knowledge: $r = 1.00$, $p < .001$; form: $r = .92$, $p < .001$), as for English (semantic content: $r = .96$, $p < .001$; self-estimated knowledge: $r = 1.00$, $p < .001$; form: $r = .96$, $p < .001$). Internal reliability of the word definitions task was calculated with Cronbach's alpha and was found

acceptable in both French (semantic content: α = .79; self-estimated knowledge: α = .74; form: α = .74) and English (semantic content: α = .82; self-estimated knowledge: α = .81; form: α = .80).

Results

Word Definition Performance in French across Language Groups

Performance on the word definition task was analyzed on the three variables: semantic content, self-estimated knowledge, and form (descriptive data is available in Table 3 and a visual illustration in Figure 1), and further sub-divided into subject words (everyday, math, and science).

Semantic content. A visual examination of mean performance in French on semantic content of the bilingual and monolingual children per item shows that the groups performed at similar levels across most items and that item difficulty varied largely (see Figure 2). An analysis of the distribution of responses with full, partial, or no meaning, showed similar profiles between the language groups. All groups scored zero points (no meaning) on the majority of items (around 60%) and the rest of the answers were divided between scoring one point (partial meaning) and two points (full meaning).

To statistically compare performance on the semantic content of word definitions in French across language groups, a one-way ANOVA was conducted with content total as dependent variable (DV) and groups as independent variable (IV; Bil-Sim, Bil-Seq, and Mon). The result showed no significant differences between groups ($F(2, 43) = .48$, $p = .625$). Further, we conducted three separate one-way ANOVAs looking into performance across subject words (DV: everyday, math, and science words). The results revealed no significant difference on any

of the subject words between language groups (everyday: $F(2, 43) = .25$, $p = .782$; math: $F(2, 43) = .24$, $p = .791$; science: $F(2, 43) = .77$, $p = .468$).

Self-estimated knowledge. Similar statistical analyses were conducted comparing performance in French across groups on the DV self-estimated knowledge. Language groups were found to differ significantly on total self-estimated knowledge ($F(2, 43) = 4.47$, $p = .017$, $\eta^2 = .17$). Post-hoc Fisher's LSD showed that the Bil-Seq group was outperformed by the Mon group ($p = .005$) but also by the Bil-Sim group ($p = .042$). There was no significant difference between Mon and Bil-Sim groups. When looking at performance of subject words, the groups performed significantly differently on math words ($F(2, 43) = 4.36$, $p = .019$, $\eta^2 = .17$), but not on everyday words ($F(2, 43) = 1.97$, $p = .152$) or science words ($F(2, 43) = 2.84$, $p = .069$). Again, Fisher's LSD showed that the Bil-Seq group was outperformed by the Mon group on math words ($p = .005$).

Correlational analyses were then conducted to see if there was a significant relationship between self-estimated knowledge and semantic content on the word definitions task. The bilingual children showed a strong correlation between their self-estimated knowledge and semantic content in French ($r = .69$, $p < .001$). In contrast, the monolingual children showed no significant relationship between self-estimated knowledge and semantic content ($r = .52$, $p = .058$) but note that this correlation came close to significance.

Linguistic form. The language groups were found not to differ significantly on total score of form ($F(2, 43) = .48$, $p = .491$) or any of the subject words (everyday: $F(2, 43) = 1.01$, $p = .371$; math: $F(2, 43) = 1.10$, $p = .343$; science: $F(2, 43) = .65$, $p = .525$).

Word Definition Performance in English across Bilingual Groups

In English, performance on the word definition task was analyzed on the same variables for the two bilingual groups (see descriptive data in Table 4 and visual illustration in Figure 1).

Semantic content. Average performance on semantic content in English per item is displayed in Figure 2. A visual examination shows that the two bilingual groups performed at similar levels across most items (with the exception of carnivore). Further, a frequency distribution analysis of responses showed small differences between the two groups, and small differences compared to French with slightly more responses scoring 0 points in English.

To statistically compare the performance on semantic content between the two groups, we conducted a series of independent t tests with group as IV (Bil-Sim, Bil-Seq). The sequential learners had consistently higher mean performance, however, the difference was non-significant across any measure (total content: $t(27) = -1.27$, $p = .220$; everyday: $t(27) = -.65$, $p = .520$; math: $t(27) = -.83$, $p = .416$; science: $t(27) = -1.34$, $p = .190$).

Self-estimated knowledge. To compare performance on self-estimated knowledge in English between the bilingual groups, we similarly conducted a series of independent t tests. Again, the sequential learners performed consistently better, but the differences were non-significant (total self-estimated knowledge: $t(27) = -1.04$, $p = .308$; everyday: $t(27) = -.57$, $p = .576$; math: $t(27) = -1.79$, $p = .085$; science: $t(27) = -.52$, $p = .610$). Like for French, correlational analyses were then conducted to examine the relationship between self-estimated knowledge and semantic content. Similar to the result for French, the bilingual children showed a strong correlation between their self-estimated knowledge and semantic content in English ($r = .83$, $p < .001$).

Linguistic form. We then compared linguistic form of the word definitions for the two bilingual groups. Even though the sequential group performed better on average, the differences

were again not significant (total form: $t(27) = -1.16$, $p = .256$; everyday: $t(27) = -.78$, $p = .444$; math: $t(27) = -1.68$, $p = .105$; science: $t(27) = -.68$, $p = .505$).

Comparing Performance in French and English for the Bilingual Children

An abbreviated set of analyses was conducted to compare the performance of the bilingual children on the two languages with paired sample t-tests (means and standard deviations can be seen in Tables 3 and 4). Here, the Bil-Sim and Bil-Seq groups showed different results. The simultaneous children were found to perform significantly better in French than English on all three total measures of the word definitions task: semantic content ($t(13) = 2.54$, $p = .025$, *Cohen's d* = .76), self-estimated knowledge ($t(13) = 3.60$, $p = .003$, *Cohen's d* = .99), and form ($t(13) = 3.07$, $p = .009$, *Cohen's d* = .93). On the semantic content of subject words, the Bil-Sim group performed significantly better on science words in French ($t(13) = 2.60$, $p = .022$, *Cohen's d* = .75), but at equal levels in the two languages for everyday ($t(13) = 1.27$, $p = .225$) and math words ($t(13) = 1.76$, $p = .103$). The Bil-Seq group showed no significant differences when comparing their performance in French and English, on either the total measures (semantic content: $t(10) = .40$, $p = .698$; self-estimated knowledge: $t(10) = .62$, $p = .548$; form: $t(10) = 1.61$, $p = .138$) or semantic content of subject words (everyday: $t(10) = -.29$, $p = .779$; math: $t(10) = .00$, $p = 1.000$; science: $t(10) = .58$, $p = .578$).

Correlation between Word Definition and Vocabulary Size

Correlational analyses were conducted to examine the relationship between word definition performance and receptive and expressive vocabulary size, in French for the whole group and in English for the bilingual children (see Table 5 for statistics). In both languages, receptive and expressive vocabulary were correlated with semantic content, self-estimated

knowledge, and linguistic form, with moderate relations in French and strong relations in English.

The Effect of Language Experience

A series of correlational analyses was conducted to establish relationships between the word definition measures and language experience variables (see Table 6 for statistics). Considering that multiple tests were performed, we adjusted the α level to .01 according to Bonferroni (0.05/5 = 0.01).

Cumulative language exposure. Total amount of language exposure to French since birth was found to not correlate significantly to performance in French on semantic content, self-estimated knowledge, and form, or with semantic content on any of the subject words. Conversely, cumulative language exposure to English correlated significantly with performance in English on self-estimated knowledge and form, and came close to significance for total measure of semantic content. Further, cumulative exposure to English correlated significantly with math and science words in English, but not everyday words.

Current language exposure. A similar pattern was found for current language exposure based on an average week. Current exposure to French did not correlate significantly with performance in French on semantic content, self-estimated knowledge, or form, and not with semantic content on everyday, math, or science words. Current exposure in English was found to correlate significantly with performance in English on self-estimated knowledge with the adjusted α level, and came close to significance on total measures of semantic content and form, as well as semantic content on math words.

Language exposure at home. Again, looking at language exposure at home since birth, a similar pattern emerged. Cumulative exposure to French in the home was found to not correlate

significantly with any of the total measures of word definition performance in French (semantic content, self-estimated knowledge, or form, or semantic content on everyday, math, or science words). Cumulative exposure to English in the home was found to correlate significantly with English performance on semantic content, self-estimated knowledge, and form, as well as semantic content on math and science words but not on everyday words.

Language exposure at school. The analyses on language exposure at school revealed a different pattern than the other exposure measures. All children were enrolled in French school where the curriculum was taught in French and French was the predominant language in all other activities. Despite this, there was still some variation in amount of French exposure in school (see Table 1 for descriptive data). Looking at the relationship between exposure to French in school and performance in French on the word definition variables revealed a significant correlation on science words according to adjusted α level, and came close to significance on the total measures semantic content, self-estimated knowledge, and form, as well as math words. Looking at exposure to English in school, the children had had very low amounts since Kindergarten (see Table 1). The relationship between English exposure in school and word definition performance in English variables proved non-significant for all measures.

Children with or without French exposure at home. To further investigate the impact of home language exposure, the bilingual children were divided into groups based on whether they had any French exposure at home or not. Twelve children had no French at home (amount of exposure: $\bar{x}$ = .00, *SD* = .00), and 24 had at least some level of French in the home (amount of exposure: $\bar{x}$ = .56, *SD* = .32). Independent sample t-tests showed no significant difference between groups on the word definitions variables in French: semantic content ($t(30) = .62$, $p = .539$), self-estimated knowledge ($t(30) = .82$, $p = .420$), and form ($t(30) = 1.14$, $p = .264$).

Age of acquisition. In both French and English, a correlation between AoA to that language and self-estimated knowledge came close to significance, but AoA was not correlated with semantic content, form, or any of the subject words everyday, math, or science.

Discussion

The main objective of the present study was to examine differences in the ability to define words between bilingual and monolingual third-graders, in the context of their language exposure. Our findings revealed no significant differences between the bilingual and monolingual children on semantic content or linguistic form, either on total measures or subject words, despite significantly lower performance for the bilingual groups on receptive and expressive vocabulary breadth (the vocabulary size is reported on in more detail in Elin Thordardottir, in press). A smaller vocabulary size for bilingual children in each of their languages compared to that of monolingual peers is widely found in the literature on vocabulary (e.g., Oller et al., 2007), as confirmed in the present study. The finding that bilingual children, at this stage of their L2 schooling, do not differ from monolingual peers on depth of vocabulary has several implications. First, it emphasizes the multidimensionality of word definitions and suggests that the scope of the task is significantly different from the measures of vocabulary size. It might be that the task of word definitions is an academic task, and as such is context-bound to a high degree, meaning that if you are schooled in one language you will perform at similar levels as monolingual peers in that language. This differs from the vocabulary size tasks, which are not bound to a specific domain or context as they typically include words from several domains. However, an alternative explanation for the lack of significant differences between language groups could also be the difficulty of the task and that all groups performed in a lower range. This could be evaluated by conducting the word definitions task in higher grades.

Further, the results imply that the lower vocabulary size scores of bilinguals are compensated for by other linguistic faculties when it comes to the task of word definitions. The tasks measure different aspects of vocabulary and engage other processes. In addition, word definition tasks have a meta-linguistic character and are predicted by syntactic, phonological, and lexical awareness (Benelli et al., 2006). Bilingual children have been suggested to have enhanced meta-linguistic awareness (see discussion in Kieffer & Lesaux, 2012), which also could augment their ability to define words. A third implication is that after four years of full-time L2 schooling, the bilingual children could simply have caught up to their monolingual peers on this task. This would be in line with Schoonen and Verhallen (2008) where the differences between monolingual and bilingual groups were smaller in grade 5 compared to grade 3. Moreover, it could be explained by the children being in similar stages of literacy due to their length of schooling (cf. findings on the dependency between word definitions and literacy prediction) or it could indicate that the bilingual children have reached a critical mass of language exposure for this ability by third grade. This latter explanation is further supported in our study by the lack of a significant relationship between the word definitions task and language exposure in French.

However, another possible explanation that must be taken into account is that most of the target words were cognates in French and English. It is possible that this benefitted the bilingual children in their performance and gave them an advantage over the monolinguals, leading to on par performance. Even though we can neither prove nor disprove this explanation, it must be noted that since the children were all in French-curriculum schools, they had not received formal instruction on the math and science words in English. If a strong facilitation effect of cognates were underlying the performance, we would have expected an on par performance on everyday words but not math or science. Furthermore, when comparing performance in French and

English, the simultaneous bilingual group ought to have performed similarly in the two languages (as did the sequential group). All this to say that an effect of cognates is possible in the findings, however, it cannot solely explain the lack of differences between bilingual and monolingual groups.

Furthermore, we found that the bilingual and monolingual children differed on self-estimated knowledge. The monolingual children were more confident that they knew the words. However, there was no significant correlation between performance on semantic content and self-estimated knowledge for the monolingual children, while there was a significant relationship for the bilingual children (in both of their languages). The findings imply that the bilingual children were more realistic about their abilities, while the monolingual children appeared over-confident. Several factors could be contributing to this difference in confidence: a consequence of being schooled in your L2, the experience of actively using two or more languages, or an explicit effect of bilingualism on the language faculties. More research is needed on this topic.

When comparing the performance of the two bilingual groups on English, they showed no differences. Further, when looking within each of the bilingual groups and comparing their performance in the two languages, two main findings are revealed. First, the simultaneous learners of French performed significantly better in French on total measures and science words (but not math or everyday words), while the sequential learners of French performed at equal levels in French and English. Since both groups had received full-time French instruction since Kindergarten, this confirms that the task of word definitions is influenced by their language experience to some degree. It is possible that the Bil-Sim group had been able to benefit from school instruction to a higher degree than the Bil-Seq group, which in turn might be due to their

longer period of acquiring French and a higher degree of cumulative language exposure to French.

Our second research question addressed the issue of how language exposure affects the ability to define words for bilingual third-graders. For an in-depth examination of the contexts of language exposure, four different measures were calculated: cumulative exposure since birth, current exposure based on an average school week, amount of exposure at home since birth, and amount of exposure in school since Kindergarten (total of four years). The French word definitions task was not correlated significantly with cumulative, current or home exposure. This opposes the findings on vocabulary breadth measures for the same sample of children (Elin Thordardottir, in press) and could be explained by the differences in the nature of the tasks as discussed above. But it is also possible that the children in this study may have reached their threshold level of exposure for the word definitions task at this stage of their schooling. Most of the studies looking at effects of exposure have focused on children attending preschool or earlier grades. This line of reasoning is also supported by the lack of differences in French between bilingual and monolingual children in this study. Moreover, looking within the bilingual group on the word definitions task in English, cumulative, current, and home exposure is moderately to highly correlated with word definition measures in that language. Since the children are all in French school, they have been exposed to proportionately smaller amounts of English, at least for the past four years. Due to these stronger correlations in English, compared to French, it is plausible that a threshold effect of language exposure exists for word definitions (cf. findings on vocabulary breadth; Elin Thordardottir, 2011) as the children have reached this level in French but not in English. At the same time, most children perform in the lower range of the task, which implies that another factor is at play here. If exposure was the most important factor and the

children have reached a threshold level in French, they ought to have performed better in French. Clearly, the ability to create word definitions is not mainly dependent on amount of exposure.

When looking at amount of exposure to French in school, an opposing pattern emerged. Even though all of the children were educated in French school with the curriculum taught in French only, they differed somewhat in their exposure to French in school since Kindergarten. Despite this rather small variation in French exposure, the amount of school exposure correlates significantly with performance on word definitions. Conversely, and as expected, their limited exposure to English in school had no effect on the English task. For this school-like task, exposure at school has a larger effect than the other exposure measures, pointing to the context-dependency of the effect of language exposure. Furthermore, we compared the performance between children with and without French in the home to see if additional French outside of school would give an extra boost, and found no significant differences, meaning that more is not always better.

Additionally, looking at AoA, the results showed that the age at which the children started acquiring the language had a negative impact on their self-estimated knowledge in that language, but not on semantic content or form. Moreover, the Bil-Sim and Bil-Seq groups performed at similar levels across all word definitions measures on both French and English with the exception of self-estimated knowledge. Thus, our study found no differences in vocabulary depth between early and late learners of French, as supported in other recent studies (Elin Thordardottir, in press; Unsworth, 2016). However, the significant correlation between self-estimated knowledge and AoA to that language highlights an influence on confidence of vocabulary knowledge, which is interesting as this was also the only variable where the bilingual children differed from the monolingual group. Self-estimated knowledge thus appears to be the

variable most sensitive to language experience, with effects both of being bilingual or monolingual and AoA, and, as discussed above, warrants further investigation.

Looking at the present study, the question arises: is word definitions a useful measure of depth of vocabulary in bilinguals? The study showed that the task is certainly different than receptive or expressive vocabulary size. Even though the tasks are correlated with each other, the scope is different and a lower vocabulary size does not seem to impair performance on word definitions in third grade. One major aspect of word definitions is its academic nature. It is a function that is taught and used in school, to a much larger degree than in other environments. As such, maybe word definition tasks capture the ability to create definitions more than actual degree of word knowledge. Apart from conveying word meaning, the task also involves the ability to conform to the formalities of academic language. In this study, we separated linguistic form from semantic content in the analysis but both measures revealed the same results: there were no differences between bilingual and monolingual groups. The bilingual children were able to compensate for their lower vocabulary size. This suggests an area of strength, possibly due to the multidimensionality and meta-linguistic character of word definitions. As such, it is not only a measure of vocabulary depth. Then, what does it predict for the academic performance of bilingual children? More research is needed on the predictive abilities of word definitions in bilingual children specifically, but our findings emphasize that the task of word definitions taps into other language faculties than basic vocabulary knowledge. Further, we show that word definitions are closely tied to school exposure, pointing to the context-dependency of the effect of language exposure, and we also found some support for a threshold effect of language exposure on the task. In sum, the findings on the effect of exposure show that there is a relationship with word definitions, but this differs in nature compared to the relationship that is

seen with vocabulary breadth. Moreover, our findings implicate that L2 exposure in the home had little effect on this school-like task, which, speculatively, would support bilingual families in continuing to use the language of choice in their home without negative effects on depth of L2 vocabulary if the child is educated full-time in L2. However, further research is needed.

In conclusion, despite lower performance for bilinguals on vocabulary breadth and documented difficulties for bilingual students to keep up with monolingual peers if in L2-schooling (OECD, 2010), this study found an area of bilingual strength. Even though there is an effect of language exposure, this does not in full explain what contributes to the depth of vocabulary knowledge in bilingual school-aged children. Our findings on word definitions lead to speculations on the importance of meta-linguistic skills and the ability to utilize academic instruction. The bilingual strength discerned in our study opens up for more research narrowing in on that strength, which will lead to insights on how depth of vocabulary is achieved as well as how to best support L2 word learning in school.

Limitations and Future Directions

The present study focused on bilingual children in a monolingual school setting, a common scenario for most bilingual children. A next step would be to examine how children educated in bilingual programs would perform on the task in their two languages. Since the participants in our study appeared to have reached their threshold level of exposure to L2 by third grade, we suggest examining word definitions with an adapted task in lower grades to be able to pinpoint when the critical mass of exposure is reached. We also suggest conducting studies in higher grades with the same task, to examine if the difficulty of the task would decrease and yield larger differences between groups. Further, since the bilingual children in this study performed on par with monolingual peers on word definitions, but lower on vocabulary

size, more research is needed to establish what processes might underlie this discrepancy. Such research might be able to uncover linguistic faculties where bilinguals are at an advantage, and in that way highlight how bilingual students can be supported in their academic achievements.

Table 1

Descriptive data for age of acquisition to French and English as well as exposure measures for the bilingual and monolingual children. The bilingual children are further divided into simultaneous and sequential learners of French (Bil-Sim and Bil-Seq, respectively).

	Monolingual group	Bilingual group	Bil-Sim	Bil-Seq
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
AoA[1], French	.00 (.00)	21.64 (27.27)	4.29 (9.18)	56.33 (14.87)
AoA[1], English	56.00 (18.31)	16.17 (24.58)	17.58 (25.11)	13.09 (24.27)
Language exposure over lifetime, French	.99 (.01)	.47 (.29)	.62 (.24)	.19 (.12)
Language exposure over lifetime, English	.01 (.01)	.35 (.27)	.31 (.23)	.45 (.32)
Language exposure current, French	.97 (.03)	.63 (.24)	.73 (.19)	.36 (.13)
Language exposure current, English	.02 (.03)	.30 (.24)	.26 (.21)	.42 (.28)
Language exposure at home, French	1.00 (.00)	.38 (.38)	.53 (.36)	.06 (.15)
Language exposure at home, English	.00 (.00)	.41 (.36)	.36 (.34)	.50 (.40)
Language exposure at school, French	.97 (.02)	.90 (.14)	.92 (.12)	.85 (.16)
Language exposure at school, English	.03 (.02)	.09 (.13)	.08 (.12)	.12 (.15)

[1]Measured in months

Table 2

Means and standard deviations on background measures for the bilingual and monolingual groups, as well as statistics of group comparisons.

	Bil-Sim	Bil-Seq	Monolingual	Group comparisons		
	Mean (SD)	*Mean (SD)*	*Mean (SD)*	*F*	*df*	*p*
Age (months)	105.75 (4.80)	108.58 (7.12)	105.71 (4.10)	1.33	2, 47	.274
Maternal education (years)	17.26 (2.82)	16.67 (3.70)	18.57 (1.83)	.94	2, 46	.399
Non-verbal IQ[1]	109.61 (15.00)	98.64 (15.78)	112.36 (14.73)	2.83	2, 45	.070

[1] Measured with Leiter-R

Table 3

Descriptive data for the lexical tasks in French across groups. The bilingual children are also divided into early and late learners of French (Bil-Sim and Bil-Seq, respectively).

	Monolingual group	Bilingual group	Bil-Sim	Bil-Seq
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Receptive vocabulary[1]	124.64 (15.42)	102.75 (25.08)	109.46 (20.51)	98.64 (15.78)
Expressive vocabulary[2]	43.07 (7.43)	33.58 (9.25)	35.29 (9.01)	30.17 (9.12)
Word definition: semantic content				
- Total score (max 44)	13.43 (5.37)	13.16 (5.74)	13.90 (5.51)	11.92 (6.14)
- Everyday, average score (max 2)	.75 (.31)	.76 (.25)	.79 (.24)	.72 (.27)
- Math, average score (max 2)	.39 (.24)	.40 (.31)	.43 (.29)	.36 (.36)
- Science, average score (max 2)	.67 (.30)	.61 (.35)	.66 (.36)	.52 (.34)
Word definition: self-estimated knowledge				
- Total score (max 44)	27.86 (5.17)	23.63 (6.88)	25.40 (6.93)	20.67 (5.93)
- Everyday, average score (max 2)	1.25 (.31)	1.12 (.30)	1.17 (.33)	1.02 (.23)
- Math, average score (max 2)	1.12 (.31)	.83 (.44)	.93 (.41)	.67 (.44)
- Science, average score (max 2)	1.43 (.34)	1.27 (.36)	1.36 (.37)	1.12 (.31)
Word definition: form				
- Total score (max 44)	18.07 (5.00)	18.53 (5.61)	19.40 (5.80)	17.08 (5.18)
- Everyday, average score (max 2)	.81 (.26)	.91 (.23)	.93 (.23)	.86 (.23)
- Math, average score (max 2)	.66 (.25)	.57 (.34)	.62 (.34)	.49 (.34)
- Science, average score (max 2)	.99 (.31)	1.04 (.33)	1.09 (.35)	.96 (.28)

[1]Raw scores, measured with the EVIP.

[2]Raw scores, measured with Expressive vocabulary subscale from the CELF.

Table 4

Descriptive data for the lexical tasks in English for the bilingual as one group and divided into early and late learners of French (Bil-Sim and Bil-Seq, respectively).

	Bilingual group	Bil-Sim	Bil-Seq
	Mean (SD)	Mean (SD)	Mean (SD)
Receptive vocabulary[1]	112.29 (29.62)	111.00 (31.38)	114.33 (27.82)
Expressive vocabulary[2]	31.19 (12.49)	29.74 (13.51)	33.50 (10.84)
Word definition: semantic content			
- Total score (max 44)	10.03 (5.73)	9.00 (5.47)	11.73 (6.00)
- Everyday, average score (max 2)	.71 (.32)	.68 (.32)	.76 (.32)
- Math, average score (max 2)	.31 (.27)	.28 (.23)	.36 (.33)
- Science, average score (max 2)	.37 (.35)	.30 (.36)	.48 (.32)
Word definition: self-estimated knowledge			
- Total score (max 44)	17.59 (7.59)	16.44 (7.50)	19.45 (7.70)
- Everyday, average score (max 2)	1.00 (.33)	.97 (.37)	1.04 (.27)
- Math, average score (max 2)	.52 (.37)	.43 (.30)	.68 (.45)
- Science, average score (max 2)	.85 (.50)	.81 (.53)	.91 (.46)
Word definition: form			
- Total score (max 44)	13.03 (6.19)	12.00 (5.87)	14.73 (5.59)
- Everyday, average score (max 2)	.77 (.34)	.73 (.37)	.83 (.27)
- Math, average score (max 2)	.36 (.28)	.29 (.19)	.47 (.37)
- Science, average score (max 2)	.63 (.39)	.59 (.39)	.69 (.38)

[1]Raw scores, measured with the PPVT.

[2]Raw scores, measured with Expressive vocabulary subscale from the CELF-4.

Table 5

Correlational data for receptive and expressive vocabulary size and word definition measures for French (all children) and English (bilingual children).

	Receptive vocabulary, French	Expressive vocabulary, French
Word definitions, French		
- Semantic content	.52**	.47**
- Self-estimated knowledge	.61**	.41**
- Form	.47**	.41**

	Receptive vocabulary, English	Expressive vocabulary, English
Word definitions, English		
- Semantic content	.68**	.76**
- Self-estimated knowledge	.68**	.84**
- Form	.70**	.83**

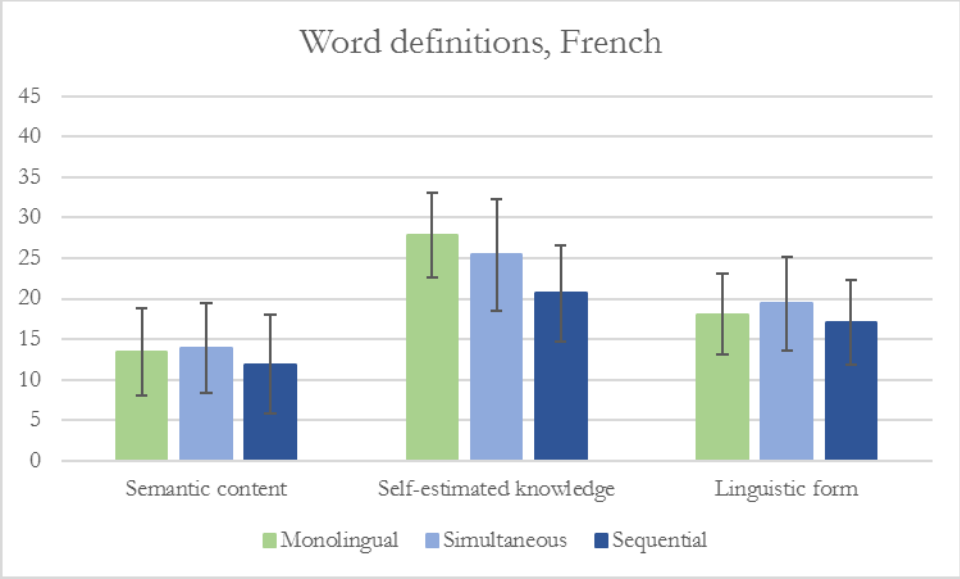
** $p < .01$

Table 6

*Correlational data for language experience variables and word definition measures for French (all children; top panel) and English (bilingual children; bottom panel). Note that Bonferroni adjusted level is α = .01 (correlations that meet the adjusted level are **bolded**).*

FRENCH					
	Cumulative exposure	Current exposure	Exposure at home	Exposure at school	Age of acquisition
Semantic content, total	.06	-.01	.32*	.03	-.12
- Semantic content, everyday	.04	-.05	.13	.04	-.10
- Semantic content, math	.02	.06	.30*	-.01	-.05
- Semantic content, science	.09	-.03	**.38****	.03	-.14
Self-estimated knowledge	.29	.29	.37*	.24	-.32*
Form	.07	.11	.29*	.05	-.10
ENGLISH					
	Cumulative exposure	Current exposure	Exposure at home	Exposure at school	Age of acquisition
Semantic content, total	.47*	.43*	-.04	**.48****	-.28
- Semantic content, everyday	.34	.25	-.09	.36	-.32
- Semantic content, math	.45*	.41*	-.06	**.48****	-.27
- Semantic content, science	**.50****	.49*	-.02	**.52****	-.20
Self-estimated knowledge	**.61****	**.55****	.08	**.61****	-.43*
Form	**.47****	.43*	-.00	**.47****	-.34

* $p < .05$, ** $p < .01$



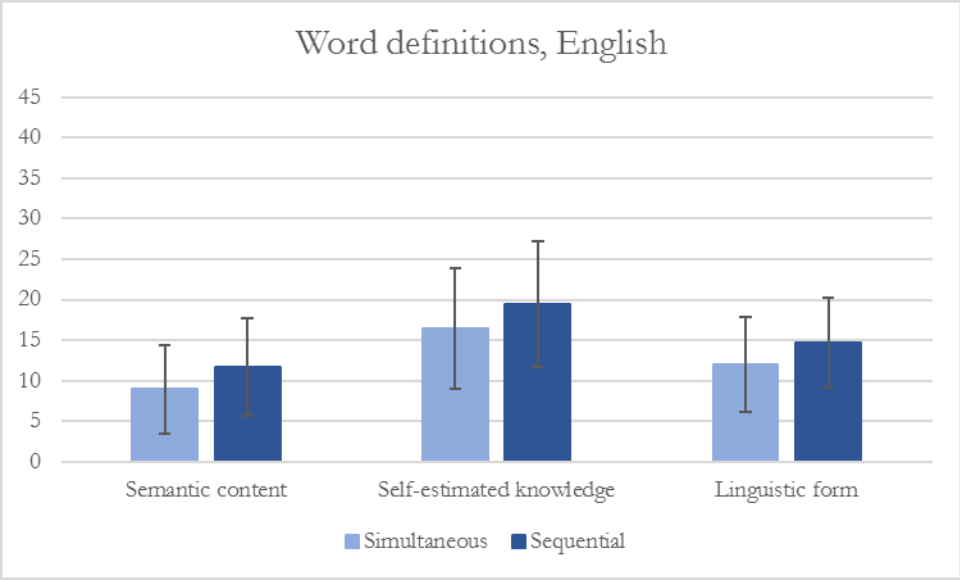
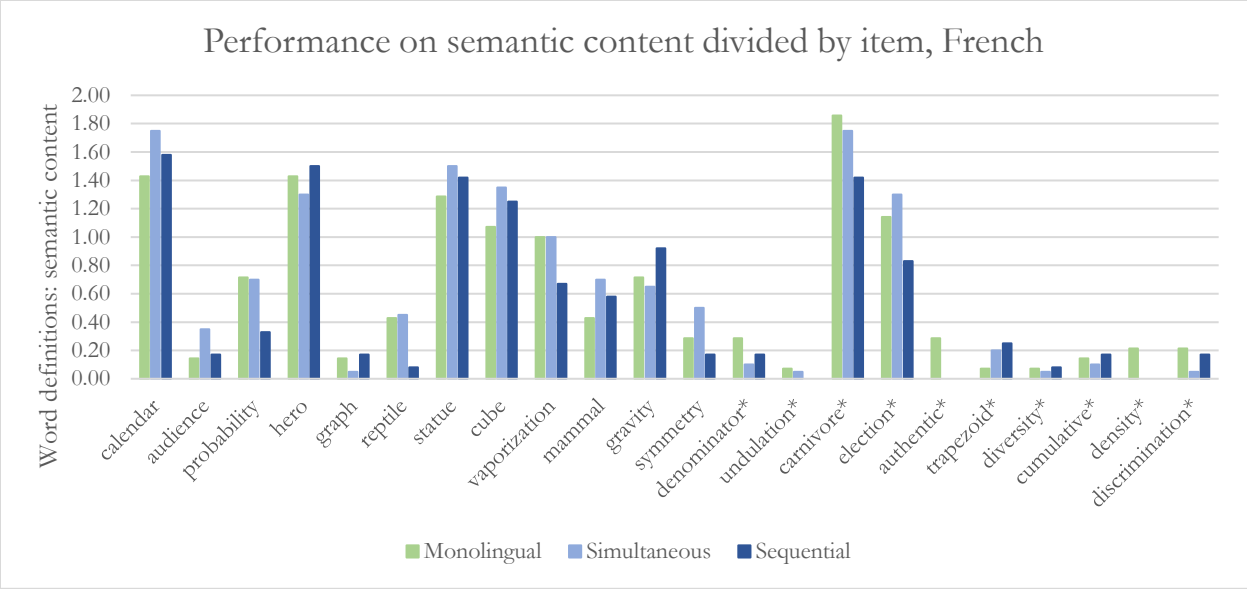


Figure 1

Mean average performance on the three scoring variables semantic content, self-estimated knowledge, and linguistic form, divided by language group, in both French (top panel) and English (bottom panel).



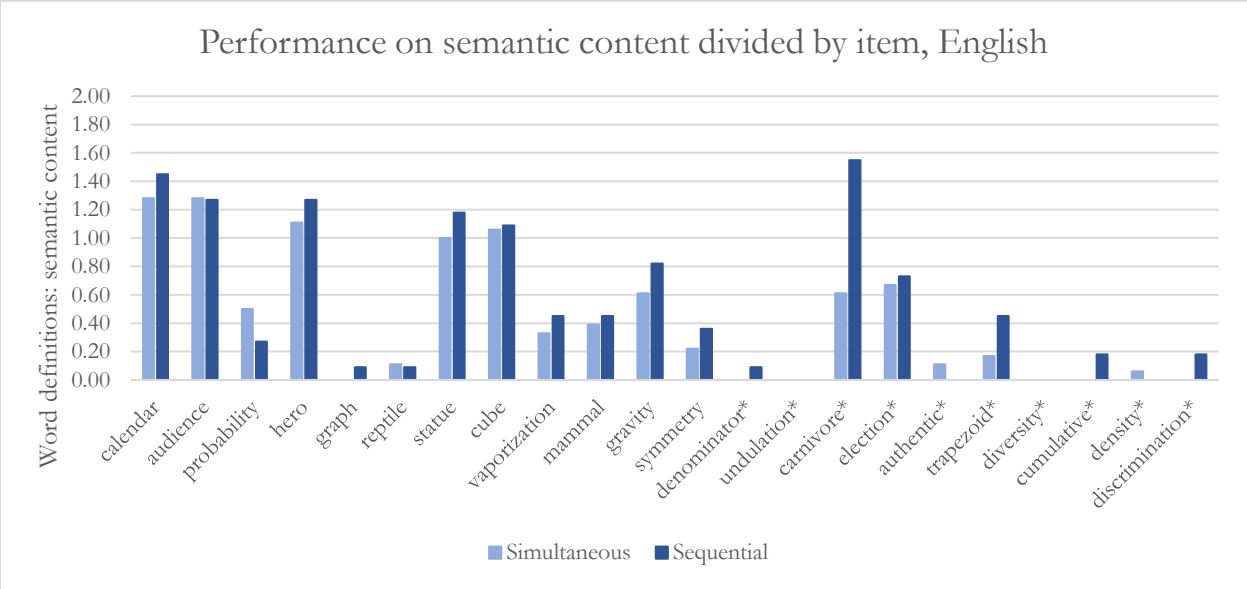


Figure 2

Mean average performance on semantic content divided by item in French (top panel) and English (bottom panel) for the language groups. Items that are classified as more difficult are marked with an asterisk (*).

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4. Preface to Study 2

In Study 1, we employed the task of formal word definitions to examine depth of vocabulary knowledge in bilingual third-graders. The findings revealed that the bilingual children performed on par with monolingual peers on semantic content and linguistic form in French, despite lower vocabulary breadth, suggesting that other language faculties and processes are involved in which the bilingual children show stronger performance compared to vocabulary size in that language. An examination of effect of language exposure for the bilingual children showed mixed results for French and English, implicating a threshold effect in amount of exposure, as this threshold has been reached in French but not in English.

An area where bilingual children are found to be at an advantage is executive functioning (Adesope, Lavin, Thompson, & Ungerleider, 2010; Barac, Bialystok, Castro, & Sanchez, 2014). Since Study 1 found that there are aspects of vocabulary depth that enable bilingual children to compensate for their smaller vocabulary size, Study 2 aimed to examine depth of vocabulary with a task that involved both vocabulary and executive functioning. Verbal fluency entails word generation under semantic or phonemic constraints and allows a comparison between verbal fluency connected to vocabulary size (semantic fluency) or phonemic organization (phonemic fluency), as well as an examination into search strategies (executive functioning). Additionally, Study 2 aimed to examine the relationship with language experience, as done for Study 1, to compare any differential effects on these two different aspects of vocabulary depth.

5. Manuscript 2

Verbal Fluency in Bilingual School-Age Children: Looking at Switching, Clustering, and the Effect of Language Experience

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Abstract

Vocabulary development is a troublesome area for bilingual children since when looking at each of their languages separately, a smaller vocabulary size is seen compared to monolingual peers. On the other hand, a suggested area of bilingual strength is executive functioning. The task of verbal fluency, word generation under semantic or phonemic constraints, combines these two areas. The handful of studies examining verbal fluency in bilingual children show performance lower than monolinguals on semantic fluency (tied to vocabulary knowledge) but on par or higher on phonemic fluency (tied to phonological processing and aspects of executive functioning). The aim of the present study was to examine the performance of bilingual school-age children on semantic and phonemic fluency in relation to their language experience. The examination of search strategies (clustering and switching) was included to further detail the aspects of lexical richness and executive functioning. The typically developing French-English bilingual or monolingual French participants in this cross-sectional study were 46 first-graders and 51 third-graders, all enrolled in French-curriculum schools. Cumulative and current language exposure was measured in detail. The bilingual children were divided into simultaneous or sequential learners of French and tested in both languages. Results showed an effect of grade on both tasks as well as an effect of bilingualism on semantic fluency but not phonemic fluency. A significant interaction effect detailed that the children performed at different levels on semantic fluency in grade 3 only. Further, no differences were seen on switching but groups differed on clustering (semantic fluency only). Simultaneous and sequential groups performed on par and amount of language exposure did not exert a strong influence. Speculatively, the findings suggest that lexical access or organization has a larger effect on performance than language exposure, but this remains to be examined.

While bilingual children display smaller vocabularies compared to monolingual peers when comparing vocabulary size in their first (L1) and second (L2) language separately (e.g., Hammer, Lawrence, & Miccio, 2008; Oller, Pearson, & Cobo-Lewis, 2007), a bilingual strength has been seen in some levels of executive functioning (see reviews in Adesope, Lavin, Thompson, & Ungerleider, 2010; Barac, Bialystok, Castro, & Sanchez, 2014). These two abilities meet in juxtaposition in the task of verbal fluency, which combines vocabulary knowledge and executive functioning by eliciting word generation under specific semantic or phonemic constraints (Hurks et al., 2010; Troyer, 2000). Research on adult populations shows discrepancies between bilinguals and monolinguals (e.g., see review in Bialystok, 2009) with the frequently emerging pattern showing lower performance for bilinguals on semantic fluency (also called category fluency) but a possible advantage on phonemic fluency (also called letter or phonological fluency). The dissociation found is often related to differences in search strategies between the two types of verbal fluency. Semantic fluency has a stronger connection to vocabulary knowledge, while phonemic fluency shows stronger relationship with phonological processing and aspects of executive functioning (Bialystok, 2009). Studies on verbal fluency in bilingual children are fewer and have shown a somewhat similar pattern to adults, with lower performance for bilinguals on semantic fluency but no difference or an advantage on phonemic fluency (Friesen, Luo, Luk, & Bialystok, 2015; Kormi-Nouri, Moradi, Moradi, Akbari-Zardkhaneh, & Zahedian, 2012). Examining bilingual performance on verbal fluency offers the possibility of seeing what the effect of bilingualism and language experience is in the interface between vocabulary knowledge and executive functioning, an area where bilingual strengths and weaknesses meet. The current paper will add two new perspectives to this examination: the effect of language experience (language exposure and age of language acquisition) and the

measurement of search strategies (clustering and switching), which will enable a discussion on how bilingual first- and third-grades employ their vocabulary knowledge and what factors might exert influence.

Verbal Fluency

The task of verbal fluency measures word retrieval efficiency under given semantic or phonemic constraints, usually under a time limitation of 60 seconds. Semantic fluency requires the participant to generate words within a semantic category, for example animals (the most commonly used category; Tombaugh, Kozak, & Rees, 1999), fruits, grocery store items, or clothes. Phonemic fluency requires the subject to generate words starting with a certain sound or letter, most commonly F, A, S, but other sounds have been used in the literature (see for example Gollan, Montoya, & Werner, 2002). Verbal fluency, and especially semantic fluency, is often used in neuropsychological assessments as a measure of vocabulary. However, the task goes beyond vocabulary as it links semantic knowledge with executive functions such as working memory, search strategies, self-monitoring, and inhibition of responses (Hurks, 2012). Phonemic fluency has been shown to be more effortful than semantic fluency in a wide range of studies. Subjects consistently generate fewer words under phonemic constraints, seen both for adults (e.g., Gollan et al., 2002) and children (e.g, Kormi-Nouri et al., 2012). Since the lexicon is not phonologically organized, searching for words based on phonemic cues is likely not a common strategy. The difference between performance on semantic and phonemic fluency is thus likely due to a discrepancy in reliance on effective shifting skills instead of in the lexico-semantic store (Troyer, Moscovitch, & Winocur, 1997). This makes verbal fluency an interesting task for examining the relationship between vocabulary knowledge and executive functioning.

When looking at the total number of words generated on verbal fluency tasks in children, a clear effect of age is seen, across languages. Older children perform better than younger children, as seen in, for example, Dutch (Hurks et al., 2010), French (Sauzéon, Lestage, Raboutet, N'Kaoua, & Claverie, 2004), Hebrew (Kavé, Kigel, & Kochva, 2008; Koren, Kofman, & Berger, 2005), Malayalam (John & Rajashekhar, 2014), Spanish (Filippetti & Allegri, 2011), and Swedish (Tallberg, Carlsson, & Lieberman, 2011). Research suggests that the development of verbal fluency continues until at least grade 7 (Hurks et al., 2010) or early adulthood (Kavé et al., 2008). Kavé and colleagues (2008) suggested that verbal fluency performance depends more on maturation of executive search strategies than lexical enrichment, but the contribution of each is not well defined (McDowd et al., 2011).

Similar age effects are seen in bilingual children, based on the few available studies (Friesen et al., 2015; Jia, Chen, Kim, Chan, & Jeung, 2014; Kormi-Nouri et al., 2012). A comparison between bilingual children and monolingual counterparts is especially interesting given that bilingualism is reported to influence executive functioning positively (Adesope et al., 2010; Adi-Japha, Berberich-Artzi, & Libnawi, 2010; Barac et al., 2014; Bialystok & Viswanathan, 2009), but vocabulary size negatively when measured in each language separately (e.g., Oller & Eilers, 2002; Pearson, Fernández, & Oller, 1993). In a large, cross-sectional study, Kormi-Nouri and colleagues (2012) compared bilingual (speaking Turkish-Persian or Kurdish-Persian) and monolingual children (speaking Persian) across grades 1-5 on semantic and phonemic fluency and found that the bilingual children were outperformed by their monolingual peers on semantic fluency, but that an advantage was found for one of the bilingual groups on phonemic fluency (as has been seen in adult populations, see for example discussion in Bialystok, Craik, & Luk, 2008). Specifically, the Turkish-Persian bilinguals outperformed

monolinguals in grade 1, but the bilingual advantage systematically decreased over the grades until there was no advantage in grade 5. The Kurdish-Persian bilinguals showed no bilingual advantage. The authors suggested that the difference in performance between the two bilingual groups might be attributed to differences in socioeconomic status (SES), cross-linguistic factors, or language proficiency.

Further, Friesen et al. (2015) compared verbal fluency in bilinguals (speaking English and another language) compared to monolinguals across ages, from children up to older adults. At age 7, there were no differences between bilingual or monolingual children on either semantic or phonemic fluency. At age 10, the monolingual group performed higher than bilinguals on semantic fluency, but no difference was seen on phonemic fluency (until adulthood, where the bilinguals performed at higher levels). Semantic fluency performance was related to age and vocabulary knowledge (as measured by receptive vocabulary size), while phonemic fluency performance was related to bilingual status. The authors suggested that degree of literacy plays a role during school-age, as the relevant skills are not automated until adulthood, but they also highlighted a connection to the maturation of executive functioning.

However, optimal fluency performance involves more than total number of words generated. It also involves systematic search strategies, the generation of words within a subcategory, and the switch to another subcategory (Troyer, 2000). To tap into these skills, that are related not only to semantic knowledge but also executive functioning, it is recommended to include measures of systematic organization, such as clustering and switching (Filippetti & Allegri, 2011; Hurks et al., 2010). Clustering words within a subcategory is dependent on verbal memory and word storage while switching relies on strategic search and the ability to switch between tasks (Troyer et al., 1997). Studies have seen a developmental effect on number of

clusters and switches generated in monolingual children until at least grade 7 and on mean cluster size until at least grade 3 (Hurks et al., 2010). Further, a correlation has been found between total words generated and switching, indicating that switching is a valuable measure of successful search strategies and executive functioning (Filippetti & Allegri, 2011). Filippetti and Allegri (2011) argue that number of switches is more important for verbal fluency performance than mean cluster size (which is more closely related to vocabulary than executive functioning). At the writing of this paper, we found only one study looking at switching and clustering in bilingual children. Gonzalez-Barrero and Nadig (2016) compared performance on semantic fluency of bilingual and monolingual children with and without autism spectrum disorder in school-age (age range: 5-10 years). In the typically developing children, which are of relevance for the current study, there were no differences between bilingual and monolingual children on total words, number of switches, or mean cluster size. As the first study of its kind, the groups were small (n = 13 in each) and the age range wide, and it is possible that a larger sample would show different and more detailed results.

Considering the advantage seen in bilingual children on cognitive flexibility (Adi-Japha et al., 2010; Bialystok & Viswanathan, 2009), adding the variables of switching and clustering will offer a more detailed examination of verbal fluency and examine the contribution of language experience to the aspects of lexical richness as well as executive functioning.

Effect of Language Experience

Language experience factors, such as amount of language exposure and age of language acquisition (AoA), have been proven to affect the lexical development of bilinguals (e.g., Elin Thordardottir, 2011; Hoff, Rumiche, Burridge, Ribot, & Welsh, 2014; Pearson, Fernandez,

Lewedeg, & Oller, 1997) and also, to some extent, executive functioning (Carlson & Meltzoff, 2008; Luk, De Sa, & Bialystok, 2011).

Lexical development. The effect of language exposure on bilingual lexical development was first shown in the groundbreaking work by Pearson and colleagues (Pearson et al., 1997; Pearson et al., 1993) where they found that expressive vocabulary size in each language is related to the amount of language input the young child had been exposed to. Elin Thordardottir (2011) measured amount of language exposure in detail by mapping exposure to each language since birth in different environments such as home and daycare. She found that this cumulative measure of exposure was strongly correlated to both receptive and expressive vocabulary size in her sample of French-English bilingual five-year-olds. Similar results have also been found for young children when measuring amount of exposure as current exposure based on an average week (Hoff et al., 2012). Less research has been conducted on school-aged bilinguals with detailed measures of their exposure levels. Recently, Elin Thordardottir (in press) extended her work to older bilingual children and examined the relationship between language experience and language development in first and third grade. She found a systematic relationship between cumulative language exposure over lifetime and expressive and receptive vocabulary size, for both grades, with slightly stronger correlations for receptive vocabulary. The present study included children from Elin Thordardottir's vocabulary breadth study.

Another language experience variable is the age of first acquisition (AoA). It is often related to ultimate L2 attainment and research has shown evidence for (e.g., Abrahamsson & Hyltenstam, 2009) and against age effects (e.g., Hellman, 2011) when looking at adult L2 mastery. In school-aged bilinguals, two recent studies have directly compared the L2 performance of simultaneous and sequential children in the areas of vocabulary and grammar,

controlling both AoA and overall amount of exposure to the two languages (Elin Thordardottir, in press; Unsworth, 2016). Both of these studies found simultaneous and sequential bilinguals to perform comparably, and thus call into question the traditional distinction between these two groups.

Executive functioning. Executive functioning in bilingual children is well researched but only a handful of studies include any details on language experience factors. Carlson and Meltzoff (2008) looked at executive functioning performance in English-Spanish bilinguals (age: 6 years) who were either bilingual from birth or who six months previously had started an immersion program where their lessons were divided equally between English and Spanish. The bilingual children were compared to monolingual peers. Results showed that a bilingual advantage on the executive functioning test battery was only seen in the early bilinguals, not the bilinguals with only 6 months of exposure, indicating that a certain level of exposure to a second language is required for an enhancement of executive functioning. In addition, Luk and colleagues (2011) found that bilingual young adults with early AoA (defined as using both languages actively before age 10 years) exhibited an advantage on a task of response inhibition compared to both monolingual counterparts and bilinguals with late AoA. The authors suggested that more experience in being actively bilingual is conducive to greater advantages in cognitive control. Further, research has also shown that executive functioning in bilinguals is not affected by cultural differences (Barac & Bialystok, 2012; Bialystok & Viswanathan, 2009), language pair similarities or language of schooling (Barac & Bialystok, 2012).

In sum, there is evidence that the experience of being bilingual affects both lexical development and executive functioning. This might be related to the act of being bilingual, the amount of exposure accumulated since birth, or current language patterns. We have not been able

to find a study looking at the effect of language exposure on verbal fluency in bilingual children, a task that combines vocabulary knowledge and executive functioning and, in that way, is different from the other tasks that have been used in exposure research. The aim of the present paper is therefore to examine bilingual performance on verbal fluency in comparison to monolingual peers but also in the context of language experience, in order to increase our understanding of how language exposure and AoA might affect the use of vocabulary knowledge and access to lexical representations.

Aims of the Current Study

The main objective of the present study was to examine performance on two verbal fluency tasks (semantic and phonemic) in bilingual first- and third-graders and compare it to that of monolingual peers as well as between the two languages. The language in common for all children was French and they were all schooled full-time in French. The aim was to look at total words generated as well as switching and clustering, to examine any potential areas of strength or weakness in bilinguals on this task encompassing both vocabulary and executive functioning. In line with the literature, it was predicted that the bilinguals would be outperformed by the monolinguals on semantic fluency (relating to vocabulary size) but that no difference would be seen on phonemic fluency (more related to executive functioning). Further, it was predicted that semantic fluency would be more closely related to language exposure measures than phonemic fluency due to the former's stronger connection to vocabulary.

Specifically, the research questions were as follows:

1. How does the performance of bilingual children compare to that of monolingual peers on semantic and phonemic fluency with respect to total words, switching, and cluster size?

2. To what extent is verbal fluency performance (measured as total words) influenced by amount of language exposure (measured as cumulative and current) and age of acquisition?
3. How do French-English bilingual children, schooled full-time in French, compare on verbal fluency performance in their two languages?

Method

Participants

The participating children ($N = 97$) were enrolled in first ($n = 46$, mean age at testing: 6;9, mean age in months = 81.98, $SD = 5.46$) and third grade ($n = 51$, mean age at testing: 8;9, mean age in months = 106.88, $SD = 5.62$) in French-language schools at the time of recruitment and testing. The children were typically-developing and recruited from the greater Montreal area as part of a larger study conducted in the second author's lab. The aim was to recruit both simultaneous and sequential learners of French, with a variety of amount of language exposure to French. To be judged as monolingual for the purposes of this study, the children needed to have no other language than French at home, to have had very limited exposure to English at school (less than 5% cumulative exposure to English since birth), and be deemed functionally monolingual by their parents (i.e., not able to participate in any level of testing in a language other than French). The bilingual children were divided into groups of simultaneous (early) and sequential (late) learners of French depending on the age of first acquisition with a cut-off set at 36 months (cf. McLaughlin, 1978). The groups were as follows (with number of participants in parentheses):

- Grade 1 ($n = 46$)
    - Bilingual simultaneous learners of French ($n = 21$; Bil-Sim)

    - Bilingual sequential learners of French (*n* = 9; Bil-Seq)
    - Monolingual learners of French (*n* = 16; Mon)
- Grade 3 (*n* = 51)
    - Bilingual simultaneous learners of French (*n* = 22; Bil-Sim)
    - Bilingual sequential learners of French (*n* = 15; Bil-Seq)
    - Monolingual learners of French (*n* = 14; Mon)

Descriptive data of the children's age of acquisition to French and English, as well as levels of language exposure can be seen in Table 1.

To obtain information about the children's general and language development, parents were asked to fill in a detailed background questionnaire, which included detailed questions about how much time the child had been exposed to each language across different environment (e.g., home, daycare, school) since birth. This questionnaire has been used extensively in previous studies (see Elin Thordardottir, 2011; Elin Thordardottir, Rothenberg, Rivard, & Naves, 2006). The parents also filled in a language activity diary, describing what languages the child listened to or spoke in an average school week for all the awake hours of each day. This diary was developed by the second author and is currently being used and evaluated. The background questionnaires were collected for all children. However, the language activity diaries for 10 of the children were not received despite repeated efforts to retrieve them. If anything was unclear in the parent report, clarification was sought either by telephone or personal conversation.

By Quebec law, all instruction in French schools must be in French. Seven of the participants went to schools where the curriculum was exclusively taught in French, but where the children also had extra hours in Greek or Armenian, for one and six children respectively, for

activities outside the core curriculum. Forty-four of the children were also exposed to a third language ($\bar{x}$ = .41, *SD* = .26) and eleven of them to a fourth language as well ($\bar{x}$ = .12, *SD* = .15).

As per parent report, all but two of the children had typical language and general development without neuropsychiatric delays. Parents of two children in third grade reported medicated ADHD but the children were included in this sample as they participated well in testing and scored within normal range on the non-verbal brief IQ screening (a task requiring focus and attention for a larger length of time). Hearing was screened with a portable audiometer in the first session (20dB HL at 1, 2, and 4 kHz – a response at 0.5 kHz could not always be obtained due to ambient noise). Non-verbal IQ was assessed with the brief scale of Leiter-R (Roid & Miller, 1997). See Table 1 for descriptive data of background variables. For each grade separately, a one-way independent ANOVA between language groups was conducted and showed no significant differences in age, maternal education, or non-verbal IQ as measured by Leiter-R for either grade 1 (age: $F(2, 46) = 2.28$, $p = .113$; maternal education: $F(2, 44) = .13$, $p = .880$; non-verbal IQ: $F(2, 46) = .08$, $p = .925$) or grade 3 (age: $F(2, 51) = 2.27$, $p = .114$; maternal education: $F(2, 50) = 1.20$, $p = .312$; non-verbal IQ: $F(2, 50) = 1.01$, $p = .373$).

Procedure

Participants were recruited as part of a larger study conducted in the second author's research laboratory throughout the school year over a period of three years. The children were recruited mainly from public and private schools after obtaining written permission from the principal or school board and by distributing letters informing about the study to all parents with children in first and third grade. Parents registered their interest by either mail, telephone, or email. They were then contacted by a bilingual research assistant to ascertain eligibility, before receiving a consent form detailing the study and their participation. Children were also recruited

via summer camps, after-school activities, and public postings, with the same recruitment procedure as that of schools.

The children were seen in one or two sessions, depending on their bilingual ability. If the child was judged to not possess minimal proficiency in English based on parent report, only French was assessed. English and French were tested in separate sessions and with separate examiners. If the child was judged to have sufficient English ability to be tested in English, only French was assessed. The order of language tested was counterbalanced across the group. All bilingual children completed testing in French, but three of the children deemed testable in English did not complete testing in that language as the parents could not be reached for the scheduling of a second session. Testing took place at the research laboratory or one of several testing locations across the greater area of Montreal, at the convenience of the families. All testing locations were in closed and quiet rooms where the child was alone with the examiner, and sometimes the parent at the parent's initiative. As the tasks were part of a larger test protocol, the sessions took 1.5-2 hours, with one or two breaks in between. The order of tasks within each session was not set but dependent in part on children's attention levels and interest. All sessions were video-recorded in their entirety for later analyses and transcribing. Due to some technical difficulties, not all of the sessions were recorded, and some bilingual children are therefore missing data for one of the languages since offline transcription was not possible.

Measures

Background measures. Several language experience measures were calculated based on parent report (background questionnaire and language activity diary):

1. Cumulative amount of exposure total over lifetime, across various environments (to each language to which the child had been exposed)

2. Current amount of exposure based on an average week (to each language to which the child had been exposed)
3. Age of language acquisition (to French)

Proficiency measures. Receptive vocabulary size was measured with Échelle de vocabulaire en images Peabody (EVIP - the Quebec French equivalent of the Peabody Picture Vocabulary Test; Dunn & Theriault-Whalen, 1993) in French and the Peabody Picture Vocabulary Test-III (PPVT; Dunn & Dunn, 1997) in English. Expressive vocabulary size was measured with the subscale Expressive Vocabulary from the standardized Quebec French Évaluation clinique des notions langagières fondamentales (Semel, Wiig, Secord, Boulianne, & Labelle, 2009) and its English equivalent Clinical Evaluation of Language Fundamentals-Fourth Edition (CELF-4; Semel, Wiig, & Secord, 2003). For the receptive and expressive tasks only raw scores were used, due to the bias of using norms based on monolingual populations. The results of the receptive and expressive vocabulary size tasks and their relation to exposure variables are reported in Elin Thordardottir (in press).

Semantic fluency. The verbal fluency task consisted of a semantic and a phonemic subtask, always starting with semantic fluency. For both subtasks, the children were instructed to give as many words as they could think of within a minute. Semantic fluency began with a demonstration item (clothes), where the child got assistance and feedback. Then followed the main task where the child was instructed to think of as many animals as possible in one minute. No other restrictions or feedback were given. The category animals was chosen as it is the most used semantic category for verbal fluency (Tombaugh et al., 1999). Further, the category of animals is culturally neutral and is likely talked about both in the home and in school.

Phonemic fluency. After completion of the semantic fluency task, the children were told that they were going to do something different and their attention was directed to the fact that words start with different letters. After giving demonstration items by focusing on the initial letter of the child's and examiner's names, some examples were also given starting with the sounds /m/ and /k/. The child was then instructed that the main task would begin and one minute was given for each of the sounds /f/, /a/, and /s/. These sounds were chosen due to their frequent use in the literature (see e.g., Tombaugh et al., 1999). For adults, it is common to restrict to no proper names or derived words (e.g., making plurals of words already generated), but considering the young age of the participants no other restrictions were given (see also Kormi-Nouri et al., 2012).

Data Scoring and Reliability

The receptive and expressive standardized vocabulary tasks were scored by the examiner according to the manual of the respective test and raw scores were used exclusively, due to the bias of using monolingual norms for bilingual populations.

Scoring of the verbal fluency tasks was based on the procedures introduced by Troyer et al. (1997) and used elsewhere (e.g., Hurks et al., 2010; John & Rajashekhar, 2014; Kavé et al., 2008; Tallberg et al., 2011). The scoring consisted of three variables for each of the subtasks: total number of correct words, number of switches, and mean cluster size. Total number of correct words referred to the number of words generated within 60 seconds and excluded repetitions, words violating the constraints, code-switched words (words said in another language than the one being tested) and any other errors (e.g., neologisms). Number of switches and cluster size was based on semantic and phonological clustering. Semantic clustering for the semantic fluency subtask was constructed based on the procedure in Troyer et al. (1997) and

were clustered according to: 1) habitat, 2) zoological family, 3) family members, 4) human use. For the phonemic fluency, words were clustered semantically if they were: 1) super- or subordinates, 2) within the same semantic category, 3) had a close semantic or contextual relationship. The criteria for phonological clustering were the same for both semantic and phonemic fluency and established whether the words shared any of the following characteristics: 1) same two initial phonemes, 2) differ only in regards to one vowel, 3) rhyme, 4) homonyms. Clusters included errors and repetitions and could be just a single word (Troyer, 2000). If clusters overlapped, the overlapping items were assigned to both clusters. If a larger cluster contained a smaller cluster, only the larger cluster was counted. Based on the clustering, number of switches was calculated as transitions between clusters. Mean cluster size was calculated starting with the second word in a cluster and included errors and repetitions (following Troyer et al., 1997). A single word had a cluster size of zero, a two-word cluster had a size of one and so on. To calculate mean cluster size, all cluster sizes were added up and then divided by total number of clusters (for detailed examples of clustering, see Troyer et al., 1997).

In the literature, there has been a debate as to whether number of switches should be analyzed as a ratio score by dividing the total number of switches by the total number of words generated (see e.g., Sauzéon et al., 2004). However, as argued by Troyer (2000), since the aim is to measure whether frequent switching increases total number of words generated, correcting switches for total words would be equivalent to correcting a cause for its effect, and would not represent the behavior under examination: the ability to switch. In the present paper, number of raw switches will therefore be used as an index of switching. Further, variables of the phonemic task were calculated as the average of the three phonemes /f/, /a/, and /s/ by dividing the total

score of the three phonemes by three. All analyses were done with this average score for phonemic fluency (as Bialystok et al., 2008; Friesen et al., 2015).

Reliability was calculated by rescoring 20% of the data for both French and English. The rescoring was done by a trained research assistant, using the scoring schemes. Inter-rater reliability was very high for total words in both French (semantic: $r = .92$, $p < .001$; phonemic: $r = .98$, $p < .001$) and English (semantic: $r = 1.00$, $p < .001$; phonemic: $r = .99$, $p < .001$) and varied somewhat but was still high for number of switches in French (semantic: $r = .73$, $p = .001$; phonemic: $r = .96$, $p < .001$) and English (semantic: $r = .67$, $p = .025$; phonemic: $r = .98$, $p < .001$). Inter-rater reliability for mean cluster size proved to be fair in French (semantic: $r = .61$, $p = .016$; phonemic: $r = .68$, $p = .004$) and high in English (semantic: $r = .80$, $p = .003$; phonemic: $r = .75$, $p = .013$).

Results

Verbal Fluency

The main objective of the current study was to examine bilingual performance on verbal fluency in French in grade 1 and 3 compared to monolingual peers (descriptive data for all groups can be seen in Table 2). Performance across tasks and groups is depicted in Figure 1 and the main comparisons are illustrated in Table 3.

Total number of words. To see how the whole group of children performed on semantic compared to phonemic fluency, we first conducted a paired samples t test with all participants, which showed that they performed significantly better on semantic fluency compared to phonemic fluency with a very large effect size ($t(88) = 16.63$, $p < .001$, *Cohen's d* = 2.09). Further, to compare performance between groups on total number of words generated on semantic fluency we conducted a two-way ANOVA with total words as dependent variable (DV)

and grade (2 levels: grade 1, grade 3) and language group (3 levels: Bil-Sim, Bil-Seq, Mon) as independent variables (IVs). Results showed a main effect of both age ($F(1, 86) = 10.37$, $p = .002$, *partial* $\eta^2 = .11$) and language group ($F(2, 86) = 6.85$, $p = .002$, *partial* $\eta^2 = .14$), as well as an age by language group interaction ($F(2, 86) = 3.58$, $p = .032$, *partial* $\eta^2 = .08$). The older group produced significantly more words than the younger group. Post hoc Hochberg GT2, chosen due to unequal group sizes, showed that the Mon group outperformed both the Bil-Sim ($p = .012$) and the Bil-Seq groups ($p = .015$). The Bil-Sim and Bil-Seq groups performed on par ($p = .985$). Tests of simple effects showed that language groups differed in grade 3 ($F(2, 86) = 9.95$, $p < .001$) but not grade 1 ($F(2, 86) = .44$, $p = .644$).

We then turned to phonemic fluency and compared total number of words generated with a two-way ANOVA (DV: total words phonemic fluency, IV: grade, language group). Results showed a significant main effect of age ($F(1, 88) = 14.81$, $p < .001$, *partial* $\eta^2 = .14$), indicating that children in grade 3 performed better than children in grade 1. No main effect of language group ($F(2, 88) = 1.64$, $p = .199$) or any interaction effect ($F(2, 88) = .05$, $p = .955$) were seen.

Number of switches. To examine any differences between grades and language groups on switching, two separate two-way ANOVAs were conducted for semantic and phonemic fluency (DV: number of switches, IV: grade, language group). For semantic fluency, there was no significant main effect of grade ($F(1, 86) = 1.86$, $p = .176$) or of language group ($F(2, 86) = .09$, $p = .919$), as well as no significant interaction effect ($F(2, 86) = 2.74$, $p = .070$). For phonemic fluency, a significant main effect of grade was found ($F(1, 87) = 7.44$, $p = .008$, *partial* $\eta^2 = .08$) where the older group outperformed the younger group. However, no significant main effect of language group ($F(2, 87) = 1.22$, $p = .301$) or any interaction effect ($F(2, 87) =$

.46, p = .636) was seen. Therefore, on switching, an effect could only be seen of grade on phonemic fluency (see Table 3 for illustration of main comparisons).

Mean cluster size. To examine any differences in mean cluster size, we similarly conducted two separate two-way ANOVAs for semantic and phonemic fluency (DV: mean cluster size, IV: grade, language group). For semantic fluency, results showed a significant main effect of language group (F(2, 86) = 6.27, p = .003, *partial* η^2 = .13) with post hoc Hochberg showing that the Mon group outperformed both the Bil-Sim (p = .049) and Bil-Seq group (p = .005), while the two bilingual groups did not differ from one another. No significant main effect was seen of grade (F(1, 86) = 1.85, p = .178) and no significant interaction effect was seen (F(2, 86) = .23, p = .798). For phonemic fluency, there were no main effects seen of either grade (F(1, 88) = 2.17, p = .145) or language group (F(2, 88) = 2.75, p = .069) as well as no significant interaction effect (F(2, 88) = .81, p = .449). Thus, on clustering, an effect of language group was seen on semantic fluency (see Table 3 for illustration of main comparisons).

Comparing Verbal Fluency Performance of the Bilingual Children in French and English

The bilingual children's performance in their two languages on verbal fluency was examined with paired samples t tests, separately for each grade, for the subset of children that completed the tasks in both languages (see descriptive data of the verbal fluency tasks in English in Table 4). The bilingual children in grade 1 performed at similar levels in French and English, both on semantic (t(10) = .44, p = .672) and phonemic fluency (t(12) = .94, p = .368). The children in grade 3 showed no difference on semantic fluency (t(27) = 1.21, p = .238), but performed significantly better in French on phonemic fluency (t(27) = 2.54, p = .017, *Cohen's d* = .45).

Relationship Between Verbal Fluency and Vocabulary Size

Correlational analyses were conducted to examine the relations between verbal fluency tasks and vocabulary size measures, in both languages. Significant correlations were found across measures, but varying in strength. In French, receptive vocabulary size was weakly correlated with semantic fluency ($r = .27$, $p = .009$) and moderately correlated to phonemic fluency ($r = .48$, $p < .001$). Expressive vocabulary size in French was weakly correlated to both semantic ($r = .34$, $p = .001$) and phonemic fluency ($r = .35$, $p = .001$). Moderate correlations were seen in English, for both receptive (semantic: $r = .69$, $p < .001$; phonemic: $r = .59$, $p < .001$) and expressive vocabulary size (semantic: $r = .52$, $p < .001$; phonemic: $r = .45$, $p = .002$).

Effect of Language Exposure on Verbal Fluency

To examine the relationship between the verbal fluency tasks and language exposure, correlational analyses were conducted. Each verbal fluency measure was correlated to cumulative and current exposure (see statistics in Table 5). In French, semantic fluency total words was found to correlate significantly with both cumulative exposure and current exposure, as was mean cluster size. In contrast, number of switches was not correlated with either. Phonemic fluency total words was correlated significantly with current exposure, but not cumulative exposure. Mean cluster size was correlated with cumulative but not current exposure, and number of switches was correlated with neither. In English, language exposure showed weaker correlations and the only significant correlation was between semantic fluency total words and current exposure.

Discussion

The main objective of the current study was to examine bilingual performance on verbal fluency in school-age children and to compare it to that of monolingual peers. Since verbal

fluency is a task that implicates both vocabulary and executive functioning, we chose to include both semantic and phonemic fluency and to measure not only total words generated, but also number of switches and mean cluster size. Thereby, the aim was to examine any strengths or weaknesses for the bilingual children in this interface between vocabulary knowledge and executive functioning, and relating this to their levels of language exposure. Our findings were in line with previous research in that no differences were seen between bilingual and monolingual children in either grade on phonemic fluency, on any measure, despite significant differences in receptive and expressive vocabulary size between the groups (as reported in Elin Thordardottir, in press). This finding indicates an area of strength in the bilinguals, in that they can overcome their smaller vocabulary size when generating words based on phonemic cues. This is in line with the findings of the few available studies on bilingual children (Friesen et al., 2015; Kormi-Nouri et al., 2012) as well as in several studies on adult populations (see review in Bialystok, 2009), and is likely related to bilingual advantages in cognitive flexibility (e.g., Bialystok & Viswanathan, 2009) as phonemic fluency is more closely associated to executive functioning than vocabulary knowledge. It is unknown to what extent each of these skills affect verbal fluency performance (see discussion in Kavé et al, 2008; McDowd et al., 2011). Our study shows weak to moderate correlations between receptive and expressive vocabulary size and verbal fluency performance, with similar levels for semantic and phonemic fluency in French and slightly stronger correlations for semantic fluency compared to phonemic fluency in English. Thus, the findings confirm that vocabulary size does play a role even though the degree of impact is still unknown. Another possible explanation for what is seen as a bilingual strength in phonemic fluency might therefore be that if vocabulary size only plays a small role for bilinguals, there is no obstacle to overcome.

In contrast, a different pattern emerged on semantic fluency, where main effects were seen of both grade level and language group. Older children performed better than younger children and both bilingual groups were outperformed by the monolingual group. This is reflected in the findings on total words and mean cluster size (both measures of lexical richness), but not on number of switches (representing the executive functioning component of this task). The most interesting finding, as visualized in the box plots in Figure 1, was a significant interaction effect between grade and language group on semantic fluency total words, which indicates that while performance was at similar levels in grade 1, the monolingual group outperformed the bilingual children in grade 3, a pattern that was found also in 7- and 10-year-olds in Friesen et al. (2015). Thus, it appears that the bilingual children are at a standstill between first and third grade. This is a troublesome finding for the bilingual children and could be attributed to the challenges that bilingual children face in L2 schooling (e.g., OECD, 2010). Growing your vocabulary and being able to utilize the words you know are cornerstones of academic learning. Our findings show that L2 vocabulary size is not the only area of low performance for bilingual children in primary grades, but that they have increasing difficulties with word generation, despite years of L2 schooling.

Our second research question asked to what extent verbal fluency was affected by language experience, measured as cumulative or current exposure and by dividing the bilingual children into simultaneous and sequential learners of French. Looking first at the variable of AoA, we found that the simultaneous and sequential groups performed at similar levels throughout, supporting recent research questioning the division in early and late bilingual learners (Elin Thordardottir, in press; Unsworth, 2016). Further, we chose to include both cumulative and current exposure to see whether they would have a dissociative effect on the task

of verbal fluency, as it is a task that is fundamentally different from other tasks that have been used in exposure studies. Verbal fluency targets use of vocabulary knowledge and focuses on access to and generation of lexical representation. The findings indicated that, overall, verbal fluency is correlated to language exposure to a lesser degree than vocabulary size, as shown by previous studies, and, at the same time, cumulative exposure showed slightly stronger correlations with performance than current exposure. After adjusting α-level according to Bonferroni corrections, only cumulative exposure correlated with semantic fluency total words and cluster size. Moreover, the findings followed a pattern of weaker correlations for measures more associated with executive functioning, such as number of switches and phonemic rather than semantic fluency. Together, the correlational analyses show that the two components involved in verbal fluency, vocabulary knowledge and executive functioning, are most likely differently affected by amount of language exposure. This, in turn, offers clues to the real-life employment of the lexicon. While studies focusing on vocabulary size show the importance of exposure for word learning, the present study shows that exposure is not a very strong contributor to success in employing the words that have been learned. The question then arises: if exposure does not affect verbal fluency to any large extent, what might contribute more? Clearly, level of executive functioning is important for performance, and a body of research shows advantages for bilinguals in executive functioning (see review in Bialystok, 2009), interpreted as enhancing effects on the executive control system due to the continuous managing of two languages. The current study did not examine any predictors of verbal fluency performance but found that amount of language exposure is only moderately correlated to word generation. Other plausible influences could be differences in lexical representation and functioning of lexical

access. How this would affect verbal fluency performance in bilingual primary grade students is an area for future research.

Our third research question examined the performance on verbal fluency of the bilingual children in French and English. All participants were schooled full-time in French and thus had received their formal literacy instruction in French. The two languages differ largely in spelling rules and grapheme-phoneme-correspondences, which could be expected to affect verbal fluency, in particular phonemic fluency. We compared French and English performance in the subset of the bilingual children that completed the task in both languages and found that they performed at equal levels on semantic fluency in both grades and phonemic fluency in grade 1. However, in grade 3, they performed significantly better on phonemic fluency in French than in English. It is probable that this reflects two more years of formal literacy instruction and a higher degree of phonological awareness in French rather than more exposure, since the effect of language exposure on phonemic fluency was small. Further research could reveal how closely phonemic fluency is tied to phonological awareness or literacy in bilinguals. Moreover, it is noteworthy that the bilingual children are at equal levels on semantic fluency also in grade 3. This supports the notion that amount of exposure is not that strongly related to verbal fluency performance, as after two more years of full-time French schooling, larger differences would have been expected between performance in the two languages.

Taken together, the findings of the present study clearly show that the task of verbal fluency goes beyond the scope of vocabulary size and suggest the importance of executive functioning, not just in phonemic fluency but in semantic fluency as well. Thus, in this interface between vocabulary knowledge and executive functioning, the findings show that bilingual school-age children have increasing difficulties with word generation on semantic cue with age,

but not phonemically generated words, where they perform on par with monolingual peers despite a smaller receptive and expressive vocabulary breadth. Further, amount of language exposure (either cumulative or current) does not exert a strong influence. It is possible that lexical access or organization has a larger effect on performance, but this remains to be examined. The results suggest that the increasing difficulties for bilingual third-graders found here could contribute to the challenges that L2 students face in L2 schooling. Further research should look into possible predictors of verbal fluency in order to pinpoint how L2 students can be supported in their expansion and employment of vocabulary knowledge.

Limitations and Future Directions

The present study focused on the effect of language exposure on verbal fluency performance in bilingual first- and third-graders. It would be of value to extend this line of research to later grades as well, to see if the difference between bilingual and monolingual children keeps expanding with age. Further, predictors of verbal fluency in bilingual children need more examination to establish what affects performance. This could offer valuable clues to how word learning and generation in bilingual students can be strengthened.

Table 1

Means and standard deviations on background and language experience measures for the bilingual and monolingual children, as well as statistics of group comparisons.

	GRADE 1			GRADE 3		
	Bil-Sim	Bil-Seq	Mon	Bil-Sim	Bil-Seq	Mon
	Mean (SD)	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Age (months)	80.88 (5.40)	80.33 (5.10)	84.19 (5.42)	105.75 (4.80)	109.25 (7.23)	108.86 (3.94)
Maternal education (years)	18.64 (3.22)	18.00 (4.00)	18.50 (2.61)	17.26 (2.82)	17.06 (3.73)	18.57 (1.83)
Non-verbal IQ[1]	116.29 (18.19)	114.89 (21.29)	114.13 (13.47)	109.61 (15.00)	104.88 (14.40)	112.36 (14.73)
Cumulative language exposure, French	.62 (.22)	.22 (.14)	.99 (.02)	.64 (.24)	.18 (.11)	.99 (.01)
Current language exposure, French	.71 (.17)	.52 (.11)	.99 (.01)	.74 (.18)	.40 (.10)	.98 (.03)
Cumulative language exposure, English	.19 (.20)	.19 (.30)	.01 (.02)	.28 (.23)	.31 (.32)	.01 (.01)
Current language exposure, English	.22 (.16)	.17 (.21)	.01 (.01)	.26 (.21)	.26 (.27)	.02 (.03)
AoA[2], French	2.86 (6.74)	44.78 (11.64)	.00 (.00)	4.68 (9.51)	58.67 (14.75)	.00 (.00)
AoA[2], English	16.35 (23.15)	22.43 (25.44)	56.25 (21.97)	17.58 (25.11)	27.80 (35.18)	56 (18.31)

[1] Measured with Leiter-R

[2] Measured in months

* $p < .05$, ** $p < .01$

Table 2

Descriptive data for the lexical tasks in French across groups.

	GRADE 1			GRADE 3		
	Bil-Sim	Bil-Seq	Mon	Bil-Sim	Bil-Seq	Mon
	Mean (SD)	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Receptive vocabulary[1]	83.29 (23.54)	70.89 (25.44)	103.87 (15.40)	111.45 (19.11)	91.40 (26.62)	124.64 (15.42)
Expressive vocabulary[2]	30.10 (6.62)	27.56 (8.50)	34.31 (9.86)	35.77 (8.86)	30.67 (8.35)	43.50 (6.83)
Semantic fluency						
- Total words	12.47 (4.10)	11.37 (3.50)	13.07 (2.89)	13.27 (3.41)	13.20 (4.07)	19.15 (6.26)
- Number of switches	5.95 (2.68)	6.38 (2.33)	5.07 (2.01)	6.05 (2.38)	6.00 (1.89)	7.31 (1.25)
- Mean cluster size	.95 (.53)	.64 (.35)	1.40 (.80)	1.13 (.70)	.96 (.45)	1.47 (.77)
Phonemic fluency						
- Total words	4.80 (2.51)	4.33 (2.15)	5.56 (2.04)	6.88 (2.01)	6.19 (2.95)	7.31 (1.94)
- Number of switches	2.93 (1.87)	3.04 (2.14)	4.00 (1.68)	4.33 (1.45)	4.29 (2.26)	4.57 (1.71)
- Mean cluster size	.40 (.38)	.20 (.13)	.22 (.17)	.50 (.64)	.20 (.20)	.49 (.30)

[1]Raw scores, measured with the EVIP.

[2]Raw scores, measured with Expressive vocabulary subscale from the CELF.

Table 3

Illustration of the main findings in French for comparisons between grade 1 (Gr 1) and grade 3 (Gr 3) as well as comparisons between language groups (Simultaneous – Sim; Sequential – Seq; Monolingual – Mon).

Variable	Comparisons: grade level	Comparisons: language group
Receptive vocabulary	Gr 1 < Gr 3	Mon > Sim/Seq
Expressive vocabulary	Gr 1 < Gr 3	Mon > Sim/Seq
Semantic fluency		
- Total words	Gr 1 < Gr 3	Mon > Sim/Seq
- Number of switches	Gr 1 = Gr 3	Mon = Sim = Seq
- Mean cluster size	Gr 1 = Gr 3	Mon > Sim/Seq
Phonemic fluency		
- Total words	Gr 1 < Gr 3	Mon = Sim = Seq
- Number of switches	Gr 1 < Gr 3	Mon = Sim = Seq
- Mean cluster size	Gr 1 = Gr 3	Mon = Sim = Seq

Table 4

Descriptive data for the lexical tasks in English across groups.

	GRADE 1		GRADE 3	
	Bil-Sim	Bil-Seq	Bil-Sim	Bil-Seq
	Mean (SD)	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Receptive vocabulary[1]	97.77 (22.87)	108.50 (28.91)	111.00 (31.38)	105.42 (38.18)
Expressive vocabulary[2]	25.23 (10.93)	33.25 (14.52)	29.74 (13.51)	31.73 (13.75)
Semantic fluency				
- Total words	10.38 (3.43)	14.67 (6.66)	12.26 (4.78)	12.10 (3.87)
- Number of switches	5.00 (1.73)	5.33 (2.52)	6.11 (2.92)	6.50 (2.64)
- Mean cluster size	.78 (.31)	1.53 (.80)	.95 (.85)	.78 (.57)
Phonemic fluency				
- Total words	3.03 (1.58)	4.89 (.19)	5.42 (2.41)	6.13 (3.13)
- Number of switches	1.87 (1.27)	3.44 (.77)	3.61 (1.88)	4.33 (2.23)
- Mean cluster size	.19 (.25)	.21 (.07)	.29 (.31)	.34 (.22)

[1]Raw scores, measured with the PPVT-III.

[2]Raw scores, measured with Expressive vocabulary subscale from the CELF-4.

Table 5

*Correlational data for verbal fluency measures and cumulative and current exposure for French (all children; top panel) and English (bilingual children; bottom panel). Note that Bonferroni adjusted level is α = .025 (correlations that meet the adjusted level are **bolded**).*

FRENCH		
	Cumulative exposure	Current exposure
Semantic fluency		
- Total words	**.26***	.23*
- Number of switches	.03	.03
- Mean cluster size	**.28****	.24*
Phonemic fluency		
- Total words	.18	.24*
- Number of switches	.12	.17
- Mean cluster size	.21*	.20
ENGLISH		
	Cumulative exposure	Current exposure
Semantic fluency		
- Total words	.29	.32*
- Number of switches	.23	.17
- Mean cluster size	.08	.10
Phonemic fluency		
- Total words	-.07	-.15
- Number of switches	-.06	-.12
- Mean cluster size	-.09	-.13

* $p < .05$, ** $p < .01$

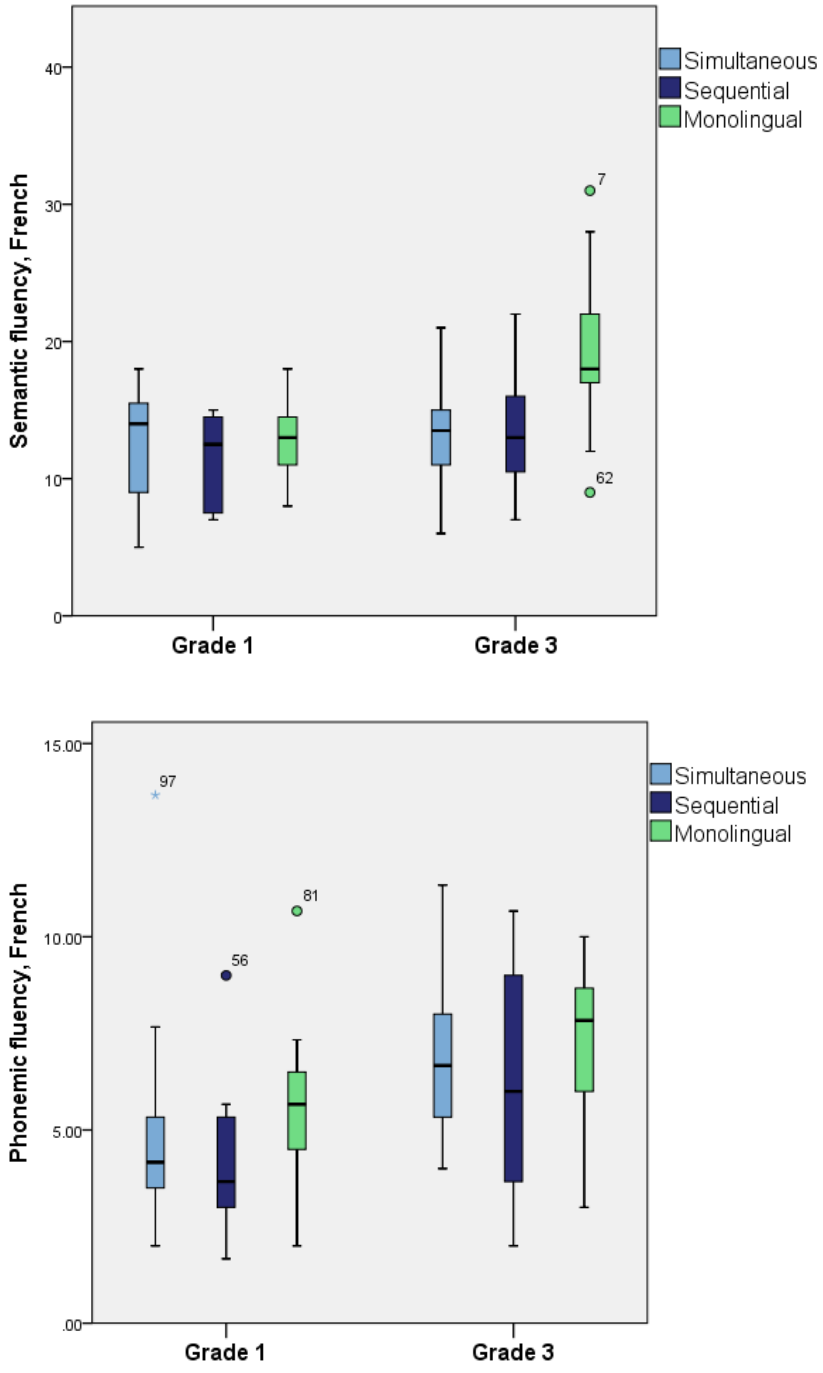

Figure 1. *Average number of words produced on semantic fluency (top) and phonemic fluency (bottom) in French, across grades and language groups.*

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6. Preface to Study 3

Study 2 examined verbal fluency across bilingual and monolingual children in grade 1 and 3. Findings showed that bilinguals performed on par with monolingual peers on variables more closely tied to executive functioning than vocabulary: phonemic fluency and switching. On semantic fluency, a negative effect of bilingualism was seen and the gap between groups was larger in grade 3, indicating that while the monolingual children had improved by grade 3, the bilingual children maintained their level of performance. These results point to a concerning weakness for the bilingual children, possibly indicating trouble acquiring new words in, for example, monolingual academic settings.

To address academic word learning, Study 3 employed an incidental word learning paradigm targeting advanced vocabulary and constructed to mimic a complex academic setting. Study 1 and 2 showed that a smaller L2 vocabulary size is not necessarily an obstacle when performing tasks of vocabulary depth, but also that depth of vocabulary appears less dependent on amount of language exposure than previously shown with vocabulary breadth. The aim of Study 3 was to examine whether bilingual input had a positive effect on incidental word learning or not, and if this was related to amount of exposure.

7. Manuscript 3

Incidental Word Learning in Bilinguals:

Does a Bilingual Context Help or Hinder?

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Abstract

Bilingual children lag behind monolingual peers when vocabulary size is compared in each of their languages. Since strong lexical skills are vital to academic achievement, it is pertinent to explore what language contexts enhance second language (L2) word learning. Our purpose was to examine how bilingual school-aged children, who are schooled in L2, can learn difficult L2 vocabulary using mixed L1/L2 input in an implicit learning situation mimicking an educational context. Bilingual French-English speaking third-graders and monolingual peers (*N* = 45) participated in this complex word learning experiment. The children's language exposure was carefully mapped in regards to overall cumulative language exposure, as well as at home and at school. Results showed that bilingual input did not significantly help nor hinder performance for the bilingual children at large. However, mean performance showed an overall trend for bilingual children with cumulative exposure over 40% to learn more in the monolingual condition. Bilingual children with as little as 20% exposure could perform within the range of their monolingual peers. Word learning performance was significantly correlated with cumulative language exposure over lifetime and at school. Further, being exposed to French in the home did not improve performance for the bilingual children. In conclusion, the results suggest that children with low L2 exposure might be helped by bilingual input to learn new L2 words; however, children with higher levels of L2 exposure might be hindered. Further, an initial discussion on establishing a critical level of exposure is offered.

Academic achievement requires strong vocabulary knowledge (e.g., Proctor, Carlo, August, & Snow, 2005), especially when academic demands increase as children grow older and educational settings become more complex. It is crucial for bilingual children to acquire the necessary vocabulary of the school language to be able to keep up with the demands they face. However, several studies show that second language students lag behind their monolingual peers when it comes to second language (L2) lexical development (e.g., Bialystok, Luk, Peets, & Yang, 2010; Hammer, Lawrence, & Miccio, 2008; Oller, Pearson, & Cobo-Lewis, 2007; Pearson, Fernández, & Oller, 1993) and are falling behind in their studies (OECD, 2010), especially in science (August et al., 2014). There is evidence that bilingual educational programs, including both the first (L1) and second language could be beneficial for L2 students (e.g., Reljić, Ferring, & Martin, 2014) but we lack the specific knowledge on what aspects of bilingual education might support word learning in bilingual children, a group with an inherently large variety of language experience and proficiency. Some educational approaches divide the classes into half L1 and half L2, giving roughly equal exposure to each language. Others mix languages within the same class or give L1 translation equivalents within an L2 context. Receiving instructions in both languages might be helpful, but we do not know under what conditions or for what types of bilingual children this would be beneficial. Are instructions in L1 always helpful, or even necessary, to learn words in L2? Research has shown a strong relationship between language exposure and vocabulary size for bilingual children up until a certain point, whereafter more exposure does not matter (e.g., Elin Thordardottir, 2011; Hoff et al., 2012). The present study set out to examine the effect of different types of language exposure on word learning under monolingual versus bilingual conditions to ask whether the amount of exposure would have an effect on whether a bilingual child, schooled in L2, is helped or possibly hindered in

their L2 word learning by bilingual instructions. This was tested with an incidental word learning experiment using mixed L1/L2 input in an implicit learning situation mimicking an educational context. The findings were considered, first, from the standpoint of a theoretical framework on the interplay between L1 and L2, and secondly, in relation to the effect of language exposure.

The Interplay Between L1 and L2

Ideas on how two languages in one bilingual individual are connected are intriguing. Many have theorized that the languages are connected and able to support each other (e.g., see review in Hamers & Blanc, 2000). One of the more famous claims of this school comes from the interdependence hypothesis put forward by Cummins (1981, 1991, 2000). The interdependence hypothesis posits that the two languages are interrelated and that a strong foundation in L1 is beneficial when learning your L2. Emerging from these ideas of interdependence between L1 and L2 are models focusing on lexical access and representation. The word association model (De Groot & Hoeks, 1995; Potter, So, Von Eckardt, & Feldman, 1984) stipulates individual levels of lexical and conceptual representations with one common conceptual representation for L1 and L2, but with separate lexicons for the languages. Access to concepts is always mediated through L1 in this model. In contrast, the concept mediation model (Kroll & Stewart, 1994; Potter et al., 1984) claims that access is possible directly to conceptual representation from either L1 or L2. In this model there is no mediation through the L1 lexicon. These models generally concern adults, but the concept can be applied to children as well (Peña & Kester, 2004). The functionality of the models is discussed in Kroll and De Groot (1997). Their developmental hypothesis puts forward the idea of a shift from the word association model to the concept mediation model based on the speaker's level of proficiency. A highly proficient L2 speaker will be able to access a conceptual representation directly from their L2 lexicon, while less proficient

speakers will need to mediate through their L1 lexicon. These two models and the developmental shift are put together in the revised hierarchical model (RHM; Kroll & De Groot, 1997; Kroll, Van Hell, Tokowicz, & Green, 2010). The RHM was developed to explain translation production of L1/L2 (see review in Kroll et al., 2010) but has also been applied to L1/L2 processing (Kotz & Elston-Güttler, 2004; Silverberg & Samuel, 2004).

The evidence for RHM comes mainly from adult studies using translation tasks. The RHM claims that changes in bilingual lexical and conceptual representations can occur due to increasing L2 proficiency and research has shown that production tasks are influenced more than processing tasks by increased proficiency (Sunderman & Kroll, 2006). The proficiency of bilingual adults is most commonly measured by self-rating, and more recently, with the addition of a language measure such as picture naming (e.g., Gullifer, Kroll, & Dussias, 2013; Sunderman & Kroll, 2006). However, there are no direct guidelines in the literature on how to establish the level of proficiency where the shift will happen. One way of testing the predictions of the RHM is the inclusion of cognates (words that share form in the two languages). For monolinguals, there should be no difference between cognate and non-cognate words, as they have only ever learned the words in one language. Bilinguals, on the other hand, can access the meaning of cognates from either language they have learned, whichever is fastest, and would show an advantage on cognates. Gullifer and colleagues (2013) found a robust cognate facilitation effect in their bilingual group, where lexical access was significantly faster on cognates compared to non-cognates in a reading task, indicating a connection between L1 and L2.

The RHM has not been applied to child word learning but it can be useful in relation to the ideas of whether bilingual children learn new L2 words through their L1 or L2. Predictions can be made that this is dependent on the level of proficiency and, by extension, it could also be

assumed that a shift in access to representations can be affected by language experience, which, in turn, has been related to proficiency (e.g., Elin Thordardottir, 2011; Pearson, Fernandez, Lewedeg, & Oller, 1997). Further, the application of the RHM framework to bilingual language development can have implications for how to best support L2 word learning.

Bilingual Input in Learning

Bilingual educational programs have been found to be beneficial for the academic achievement of L2 students, both in Europe (Reljić et al., 2014) and in the USA (Rolstad, Mahoney, & Glass, 2005, 2008; Slavin & Cheung, 2005), but there are various approaches to the levels of bilingual teaching. One approach is to divide the school week into half and half (e.g., Hemsley, Holm, & Dodd, 2014), another is to mix languages within the same class (e.g., Lugo-Neris, Jackson, & Goldstein, 2010), and a third option is to give L1 translation equivalents in an L2 context (e.g., Hennebry, Rogers, Macaro, & Murphy, 2013). Looking at mixing L1 and L2 within the same learning context provides the opportunity to examine the relationship between the two languages as well as increasing the understanding for how bilingual word learning can be supported, but there are not a lot of studies in this line of research.

Lugo-Neris and colleagues (2010) used an approach where L1 and L2 were used within the same session. They examined the impact of bilingual instructions on vocabulary acquisition in four- to six-year-old typically developing children speaking Spanish as their L1 and English as their L2. All children were judged to have limited English skills and were considered to be dominant in Spanish. Over four weeks, the children participated in shared story-reading sessions where the experimenter enhanced target items by word expansions, in either a monolingual English-only or a bilingual condition. Both groups improved in L2 receptive and expressive knowledge. Children with stronger L1 proficiency benefited the most from L1 expansions in

learning L2, while the L1 expansions in an L2 context proved not as beneficial for the low proficiency group. These results support that L1 proficiency is related, at least at this young age and to some degree, to L2 learning.

However, in a study on older children, support was found for a dependence on L2, not L1, in a learning context mixing L1 and L2 within the same context (van Laere, Agirdag, & van Braak, 2016). When bilingual fourth-graders were free to choose the language of instruction in a task using both L1 and L2, they favored L2, the school language. This was true even when they were highly proficient in L1 (their home language). The study used computer-based learning environments where the students could easily choose and switch between languages. Hence, in the younger grades, a positive effect of bilingual support within the learning context could be found but fourth-graders were more likely to choose to learn in the language of instruction rather than jump back and forth between the two languages for bilingual support. They preferred a monolingual mode of learning. One could argue that the students' preference is connected to their longer schooling in L2, which, presumably, had led to an L2 that might be stronger than L1. Relating back to the RHM (Kroll & De Groot, 1997), by fourth grade the students appear to have made the shift to directly accessing their L2 lexicon and are not dependent on L1. This might be related to their proficiency levels or language experience but it could also be that the dominant language at this point in L2 schooling had shifted from L1 to L2.

Moreover, another study also mixed L1 and L2 within the same learning context, but in the early stages of L2 learning of older students. Hennebry et al. (2013) examined whether giving L2 definitions or L1 equivalents was more beneficial for L2 word learning in ninth grade students who had been studying French as a second language in school for at least two years. Students performed better in the experimental condition with L1 equivalents than the condition

with L2 definitions, across students' proficiency levels this early on in L2 learning. This conclusion could be interpreted as giving further support for the claim of the RHM that word access is mediated through L1 in cases of low L2 proficiency (Kroll et al., 2010).

Taken together, the studies presented show that there is evidence that bilingual support is beneficial, but the findings differ depending on age, years of schooling, and level of proficiency. Bilingual input does not always help word learning but there are no guidelines as to when it is beneficial. Vocabulary size is strongly affected by language exposure (e.g., Elin Thordardottir, 2011, in press; Pearson et al., 1997) and, in turn, level of proficiency appears to affect the extent to which bilingual input is helpful or not (Kroll & De Groot, 1997; Kroll et al., 2010). It is therefore likely that amount of language exposure plays a vital role for when bilingual instruction is helpful or not, but the explicit relationship is poorly understood. Is there a point in children's language exposure where they stop mediating through L1 and are no longer helped by L1 instructions to learn new L2 words?

The Effect of Language Exposure on Vocabulary

Lexical development is strongly correlated with input, both in monolingual (Hart & Risley, 1995; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991) and bilingual children (Elin Thordardottir, 2011, in press; Hoff, Rumiche, Burridge, Ribot, & Welsh, 2014; Pearson et al., 1997; Pearson et al., 1993). The vocabulary size of bilingual children has been proven to be correlated systematically with their amount of language exposure in that language (e.g., Elin Thordardottir, 2011; Hoff et al., 2012), but less is known about other aspects of vocabulary and how words are learned in relation to the exposure a bilingual child receives. Hammer and colleagues (2008) used growth trajectories of receptive vocabulary and showed that, after starting preschool in an L2 environment, bilingual children displayed L2 vocabulary learning at

an accelerated rate for the two-year continuation of the study. Further, in that study, the children from L1-only homes learned at a faster rate than children from L1/L2-homes. This rapid vocabulary learning upon first exposure to L2 has been found also for school-age children. Elin Thordardottir (in press) examined receptive and expressive vocabulary in early and late learners of French attending first and third grade in French school (the participating third graders in the current study were part of that study). The sequential children, defined as acquiring French after the age of three years (most of them closer to school entry), showed an accelerated L2 vocabulary learning in grade 1 compared to simultaneous bilinguals; however, simultaneous and sequential learners in grade 3 did not differ in this aspect. Further, it was also shown that both receptive and expressive vocabulary size was significantly predicted by amount of cumulative language exposure since birth in both grade 1 and grade 3.

Apart from an increased rate of lexical learning upon recent exposure, there also appears to be a threshold effect in amount of exposure (e.g., see Elin Thordardottir, 2011; Hoff et al., 2012; Pearson, 2007). Elin Thordardottir (2011) showed that language performance overall increased gradually with increased input; however, bilingual five-year-olds who had had more than 40-60% cumulative language exposure since birth performed on par with monolingual peers on both receptive and expressive vocabulary size. Likewise, Hoff et al. (2012) found that a level of 40% exposure to a language, based on an average, current week, led to performance at a monolingual level for the bilingual toddlers participating in the study. Despite measuring exposure differently, cumulative since birth or current exposure patterns, these studies show that it is possible to reach a critical point where more exposure does not necessarily affect your vocabulary learning.

Additionally, when bilingual children begin their academic vocabulary learning, at the start of school, their exposure patterns often change (Hoff et al., 2014), with more L2 exposure not only in school but also in the home (Bridges & Hoff, 2014). It is unclear how this shift in exposure affects academic vocabulary learning, and, by extension, to what degree the effect of exposure might change with this new context. For example, is language exposure in school what matters for the learning of academic vocabulary or is it amount of cumulative exposure since birth that has a more general effect on word learning? Sheng, Lu, and Kan (2011) found that current exposure correlated significantly with receptive and expressive vocabulary size in L1 (Mandarin) but not L2 (English). Cohen (2016) found that both cumulative and current exposure was found to correlate with receptive vocabulary size in that language but that effects were stronger in the main school language (French) as opposed to the language spoken mostly at home (English). Furthermore, Bialystok et al. (2010) showed a difference between performance on home and school domain words in a large-scale study investigating the receptive vocabulary size of bilinguals compared to monolingual peers (age: 3-10 years). The bilingual children were outperformed by the monolingual group on the total performance as well as on the home domain words. However, on school domain words, there was no significant difference between groups.

Taken together, studies on the effect of language exposure on lexical development of bilingual children show a strong relationship that appears to vary depending on amount of exposure and context. However, the explicit effect on vocabulary learning is not well understood. Is the effect of exposure general, such that academic vocabulary learning is dependent on cumulative exposure since birth, implying an effect on a general learning device? Or is the effect directly mapped to exposure of each word, that is domain-specific in that exposure to academic words in school is the crucial factor for learning? The examination of this would offer insights to

the lexical learning mechanism of bilinguals as well as implications for support of word learning in school.

Aims of the Current Study

The main objective of the current study was to examine the effect of different types of language exposure on academic word learning under monolingual versus bilingual conditions to ask whether the amount of exposure would have an effect on whether a bilingual child, schooled in L2, is helped or hindered in their L2 word learning by bilingual instructions. This was done with a word learning experiment with monolingual and bilingual learning conditions, constructed to mimic a plausible real-life school context. Results are examined within the theoretical framework of the RHM (Kroll et al., 2010), which stipulates that dependence on bilingual input will be related to level of proficiency. The aim was to test this with children who had attended school in their L2 for a longer time to examine whether their language exposure would affect a word learning task or not, even after four years of L2 schooling. For this study, language exposure was measured as cumulative amount since birth, across home and school environments. The purpose of focusing only on cumulative exposure, and not including current exposure, was two-fold. First, accumulated exposure is the more relevant measure for establishing a critical level of exposure for a language phenomenon. Second, due to the small sample size in each experimental condition, we wanted to limit the variables included as to not lose statistical power.

It was predicted that an effect of language exposure would be seen, but that this would be dependent on amount and context. The children with high levels of exposure were predicted to not be dependent on instructions in their L1 to learn L2 words. We also hypothesized that the children with lower overall L2 exposure, for example the children without French in the home,

would be more dependent on bilingual support, presumably due to their somewhat restricted lexical knowledge.

Specifically, the research questions were as follows:

1. Does bilingual input in a complex and incidental word learning situation help or hinder L2 word learning in bilingual third-graders with four years of L2 schooling?
2. To what degree does cumulative language exposure influence word learning performance under different conditions?
3. Is it possible to establish a critical amount of exposure required for bilinguals to no longer be dependent on L1 in their L2 word learning?

Method

Participants

The participating children ($N = 45$) were enrolled in third grade in French language schools at the time of recruitment and testing (mean age at testing:8;10, mean age in months: 106, $SD = 4.01$). An additional 12 children were recruited and tested but due to technical difficulties with the software their data on the word learning experiment are missing and they were excluded from this study. Thirty-one of the participating children were bilingual English-French speakers and 14 were monolingual French speakers. The bilingual group consisted of both early and late learners of French (see Table 1 for descriptive data on age of acquisition to French as well as exposure levels). A little less than half of the bilingual children were also exposed to a third language ($n = 14$, $\bar{x} = .32$, $SD = .27$) and a minority to a fourth language ($n = 4$, $\bar{x} = .05$, $SD = .02$). To be judged monolingual for the purposes of this study, children needed to have no other language than French at home, to have had very limited exposure to English at school (less than 5% cumulative exposure to English since birth) and be deemed functionally

monolingual by their parents (i.e., not able to participate in any level of testing in a language other than French). All of the children were enrolled in French-language school. One child went to a school where the core curriculum was exclusively taught in French, but where the children also had extra hours in Greek for other activities.

Parents were asked to fill in a detailed background questionnaire answering questions on the child's general and language development, as well as account for how much time the child had spent in different language environment (e.g., home, daycare, school) since birth. This questionnaire has been used extensively in previous studies (see detailed description in Elin Thordardottir, Rothenberg, Rivard, & Naves, 2006). If anything was unclear in the parent report, clarification was sought either by telephone or personal conversation. As per parent report, all children had typical language and general development without neuropsychiatric delays. Hearing was screened with a portable audiometer in the first session (20dB HL at 1, 2, and 4 kHz – a response at 0.5 kHz could not always be obtained due to ambient noise) and non-verbal IQ was assessed with the brief scale of Leiter-R (Roid & Miller, 1997). Parents of two children reported medicated ADHD but the children were included in this sample as they participated well in testing and scored within normal range on Leiter-R brief IQ screening (a task requiring focus and attention for a larger length of time). Independent sample t tests showed no significant differences between the two groups on age, maternal education, or non-verbal IQ as measured by Leiter-R (see Table 1 for descriptive data and test statistics).

Procedure

Participants were recruited as part of a larger study conducted in the second author's research laboratory and were recruited throughout the school year over a period of three years. The children were recruited mainly from public and private schools after obtaining written

permission from the principal or school board, by distributing letters informing about the study to all parents with children in third grade. Parents registered their interest by either mail, telephone, or email. They were then contacted by a bilingual research assistant to ascertain eligibility, before receiving a consent form detailing the study and their participation. Children were also recruited via summer camps, after-school activities, and public postings, with the same recruitment procedure as that of schools.

Based on parent interview, the children were seen in one or two sessions, depending on their bilingual functionality. English and French were tested in separate sessions and with separate examiners, who were native speakers of English or French respectively. If the child was judged to not possess minimal proficiency in English, only French was assessed. Similarly, if the child was judged to have at least a low level of ability in English, that language was tested as well. The order of language tested was counterbalanced across the group and the sessions were audio-video recorded for later offline scoring and reliability.

Measures

Background measures. Based on parent reports, the following language exposure measures were calculated:

1. Cumulative amount of exposure total over lifetime, both in the home and school as well as other regular environments (to each language the child has been exposed to)
2. Cumulative amount of exposure at school since start of Kindergarten (to English and French; four years in total)
3. Cumulative amount of exposure at home over lifetime (to each language the child has been exposed to)

Proficiency measures. Receptive vocabulary size was measured in French with Échelle de vocabulaire en images Peabody (EVIP - the Quebec French equivalent of the Peabody Picture Vocabulary Test; Dunn & Theriault-Whalen, 1993). The results of the receptive vocabulary task are reported on in Elin Thordardottir (in press). For the present study, these scores were used to examine the relationship between vocabulary size and word learning. Only raw scores were used, due to the bias of using norms based on monolingual populations.

Experimental task. An experiment was constructed for this study with the aim of examining incidental word-learning under monolingual or bilingual conditions with a task that required a high level of language knowledge. The task aimed to examine the possibility of facilitating incidental learning of words in an academic text when words are defined bilingually within the same context, compared to monolingual instructions. The experiment was constructed and presented with the software SuperLab on a laptop controlled by a trained research assistant. It consisted of three phases (pre-testing, learning phase, and post-testing) as described below and included both visual text and sound stimuli. All phases were presented in a sequence without pauses in between, within the same session. In total, the experiment was estimated to take 10 minutes, but varied depending on child participation.

The text used for the task was taken from a science textbook for grade five, two grades above the participants' grade level (Leroux, Gagnon, Morin, & Lussier, 2005). Science was chosen as a topic since it is one of the areas where bilingual students have been shown to perform the weakest (August et al., 2014; OECD, 2010). The textbook was approved by the Quebec Ministry of Education and was originally written in French, then translated to English. The official textbook in both languages was used for this task, although the text has been slightly adapted. Adaptation included adding a definition of the target word after each target, and also

adding some words to create a better flow in the text. The topic of the text was the construction of bridges and the target words chosen were (French translation in parentheses): pylons (piles), corrosion (corrosion), inaugurated (inauguré), alloy (alliage), cantilever (cantilever), truss (treillis), girder (poutre), and span (travée). Note that four of these words are cognates and three words are non-cognates in order to enable an analysis of any effect on performance as a cognate facilitation effect has been seen in bilinguals as opposed to monolinguals (e.g., Gullifer et al., 2013). This task was deliberately chosen to be complex and difficult for the third-graders, in order to better be able to differentiate between the effects of each condition (the alternative being an easier task where children might hit ceiling irrespective of condition). In the experiment, the children were introduced to a fictional robot named Zolt who required the child's help to listen and learn some words. The experiment had no time limit, but children were encouraged to answer. If the children did not respond, the examiner would proceed. No repetitions of stimuli were allowed. The task was presented in one of three experimental conditions (for complete version of the texts, see Appendix B):

- Monolingual French: the entire task and all definitions were presented in French (excerpt from text with target word in *italics*: Des architectes inventifs ont donc imaginé de soutenir la structure des ponts au moyen de blocs de pierre appelés *piles* qui étaient solidement posées au fond des cours d'eau. Des *piles* sont des blocs de pierre ou de béton qui supportent les arcs d'un pont.)
- Bilingual French: pre- and post-test items were presented in French, text was presented in French with English embedded definitions (excerpt from text with target word in *italics*: Des architectes inventifs ont donc imaginé de soutenir la structure des ponts au moyen de blocs de pierre appelés *piles* qui étaient

solidement posées au fond des cours d'eau. *Pylons* are blocks of stone or concrete that support the arches of a bridge.)

- Bilingual English: pre- and post-test items were presented in English, text was presented in English with French embedded definitions (excerpt from text with target word in *italics*: Inventive architects came up with the idea of supporting bridge structures using stone blocks called *pylons* that were firmly implanted at the bottom of waterways. *Des piles* sont des blocs de pierre ou de béton qui supportent les arcs d'un pont.)

Thus, in the bilingual conditions, the children could see and listen to the text in one language where the target words were explained to a certain extent, and then have the target words explained in the other language immediately following the sentence containing the target word. This design ensured that every condition had the same number of presentations (i.e., input). Bilingual children were randomized into one of the three conditions, while the monolingual control group always performed the task in the Monolingual condition. After the loss of some participants due to technical difficulties, the groups in each condition were of unequal sizes (see Table 2 for number of participants across conditions and groups).

In the *pre-testing phase*, children's pre-existing knowledge of the target words was tested with free responses. The children were asked, for example, "What is girder?" and their response was transcribed. This phase was done to ensure that all children started off with no knowledge of the test items. For each testing, the order of the items was randomized by the software. None of the children showed a pre-existing knowledge for any of the testing items.

In the *learning phase*, children were exposed to the text with embedded definitions explaining the target words. To avoid variance due to reading skills, the children were exposed to

the text both in written and spoken form simultaneously. The sound stimuli were recorded by native speakers of each language. The text was divided into eight sections to facilitate exposure. Each target word was presented once, in direct connection with two embedded definitions (see example sentences above).

The *post-testing phase* was identical to the pre-testing. The responses were scored zero to one point, depending on partial (0.5 point) or full (1 point) knowledge.

Data Scoring and Reliability

The receptive vocabulary tasks were scored according to the manual of the respective test by the examiner. The pre- and post-testing responses of the word learning experiment were scored offline by the examiner and re-scored by the first author for reliability. The scoring scheme used was based on the definitions in the text itself and each item was scored with half a point or one point, depending on whether the knowledge was judged to be partial or full. If any response was ambiguous the video-recording was used to clarify. A more rigorous reliability check was also conducted by a trained research assistant by rescoring 20% of the data for both French and English and inter-rater reliability was found to be high ($r = .98$, $p < .001$).

Results

Word Learning Performance

Overall, the word learning task proved difficult for all children and performance is at the lower end, especially for the bilingual group (means and standard deviations for all children are presented in Table 2). A visual examination of mean performance, as displayed in Figure 1, shows that the bilingual children performed higher in the Monolingual French condition and lower in the Bilingual English condition, where the text was presented in English and the

embedded definitions were in French. Further, the monolingual group, who only did the task in French, performed better than the bilingual children, but with large variability.

Across experimental conditions. To examine any significant effects of the experimental conditions on the performance of the bilingual children, we conducted a one-way independent ANOVA including only the bilingual participants, with word learning performance as dependent variable (DV) and experimental condition as independent variable (IV; 3 levels: Monolingual, Bilingual French, and Bilingual English). The effect of experimental conditions did not reach significance ($F(2, 28) = 3.06$, $p = .063$), even though it came close.

Performance on cognates. Further, to investigate any reliance on L1 in the bilingual children, we also analysed performance on cognates versus non-cognates. Using a paired samples t test, the bilingual group was found to perform significantly differently ($t(30) = 4.67$, $p < .001$, *Cohen's d* = .97) on cognates ($\bar{x} = .28$, $SD = .27$) compared to non-cognates ($\bar{x} = .08$, $SD = .14$), with a large effect size. To examine whether this effect could be attributed to the words being cognates or not, we did a similar analysis for the monolingual group. A paired samples t test showed no significant difference ($t(13) = -.18$, $p = .857$) between cognates ($\bar{x} = .40$, $SD = .34$) and non-cognates ($\bar{x} = .42$, $SD = .25$).

Across language groups. To examine any differences in performance between bilingual and monolingual children, we compared their performance only on the Monolingual French condition since including the bilingual experimental conditions could have skewed the results of the bilingual children. An independent samples t test showed no significant difference between groups ($t(25) = 1.46$, $p = .157$).

Relationship between word learning task and receptive vocabulary. We then turned to an examination of the relationship between word learning and receptive vocabulary in French.

For the whole group of children (including both bilinguals and monolinguals), across experimental conditions, a significant correlation was found with receptive vocabulary size in French (r = .42, p = .004).

The Effect of Language Exposure

To examine the relationship between word learning performance across conditions and cumulative exposure to French, a scatter plot was created with word learning performance as a function of amount of cumulative exposure to French (see Figure 2). In the figure, the participants are marked with a shape according to experimental condition (Monolingual, Bilingual French, and Bilingual English). The mean of the monolingual group is marked as a horizontal line, as is +/- 1 SD. By examining this scatter plot, we see that the bilingual group is spread out on the exposure axis and that these children achieved higher scores in the monolingual condition than the bilingual conditions, especially the Bilingual English condition that had mostly English and embedded definitions in French. A few bilingual children performed within the monolingual range on the word learning task with as little as 20% exposure to French. Children with low exposure to French (< 40%) performed within monolingual range only if they did the word learning task in one of the bilingual conditions.

In addition, correlational analyses were conducted for French exposure. To avoid confounds arising from the two languages, we included only the children that had done the word learning task in the Monolingual condition as well as the Bilingual French condition (n = 37), as these were the conditions that contained only or primarily French and where the words were to be learned in French. Including the condition with mostly English could have skewed the results for French exposure and those children were therefore excluded. Further, due to the small sample size in the Bilingual English condition (n = 8), we did not conduct correlation analyses for

English exposure. Cumulative language exposure in French was found to correlate with word learning performance (r = .33, p = .046), as was language exposure at school (r = .38, p = .020).

We then examined the effect of having exposure to French at home or in school only. The bilingual children that had done the task in the Monolingual French or Bilingual French condition (n = 23) were divided into groups based whether they had any French exposure at home. Fifteen of the children had French at home (mean cumulative exposure to French at home: .67, SD = .33), while eight children had no French at home (mean cumulative exposure to French at home: .00, SD = .00). An independent samples t test showed no significant difference between the two groups on the word learning task as a whole ($t(21)$ = .79, p = .440).

Discussion

The aim of the present study was to examine whether bilingual input within a complex word learning situation would help or hinder the incidental learning of L2 words in bilingual third-graders and to what extent language exposure would affect their learning. Even though a pattern emerged when looking at mean performance across experimental conditions (Figure 1), statistical analyses showed that, on a group level, bilingual input appeared to neither help nor hinder L2 word learning for the whole group of bilingual children. Relating back to the RHM (Kroll et al., 2010) discussed in the introduction, these results imply that the children are not accessing their concepts through L1, as in the word association model (De Groot & Hoeks, 1995; Potter et al., 1984), but rather via a direct route in L2, as in the concept mediation model (Kroll & Stewart, 1994; Potter et al., 1984). The RHM predicts that this happens when L2 proficiency has reached a certain level. Since all the children have attended French school for four years it is arguable that their L2 proficiency level ought to be high, and this could be the reason behind the lack of significant differences between conditions. However, looking at the pattern of mean

performance in Figure 1, we see a trend towards higher performance in the monolingual condition compared to the two bilingual conditions, which leads us to speculate about a possible involvement of the L1 in L2 word learning that is too weak to show up in statistical tests. This assumption is supported by the robust finding of a facilitation effect of cognates in the bilingual group, as also found elsewhere (e.g., Gullifer et al., 2013). Thus, on a word level there is proof of a connection between L1 and L2, while on the sentence level (embedded definitions within the text) the connection appears weaker. Speculatively, it could be that the bilinguals are distracted by mixing languages within a text on a sentence level, as it requires higher processing costs, while on a word level the processing costs are lower. It might also be a case of being in a monolingual versus bilingual mode. Since the word learning task is school-like and all the children are educated in a monolingual French school, they are used to performing this type of task in a monolingual mode only, despite their bilingual background. In this context, they are not helped by bilingual definitions; possibly, they are even distracted. However, their reliance on L1 might still shine through, as it does with regards to performance on cognates, even in this L2 task.

Secondly, we examined the influence of language exposure on word learning performance. Cumulative language exposure was found to significantly correlate with word learning, just as has been shown with vocabulary size for the same children (cf. Elin Thordardottir, in press), as was language exposure in school. Despite a relationship with exposure, there were no differences between bilingual children with or without French exposure in the home, which indicates that in grade 3, after four years of L2 schooling, the amount of L2 exposure in school is enough for learning. After four years of L2 schooling, the performance of the bilingual children is independent of French exposure in the home. This could be explained by

the quality of language exposure at home being different, that is, less academic. But it could also be that four years of L2 schooling is enough to reach a critical mass of exposure.

Thirdly, our aim was to investigate the possibility of establishing a critical level of language exposure needed to perform within monolingual range. A detailed visual examination on an individual level (see Figure 2) showed that bilingual children along the exposure continuum performed within monolingual range on the word learning task with as little as 20% exposure to French, implying that that exposure is not the only factor affecting word learning performance. Further, the children with low exposure to French (< 40%) performed within the range of the monolingual participants only if they did the word learning task in one of the bilingual conditions. Thus, it appears that after bilingual children have reached a certain mass of language exposure, they are no longer helped by bilingual input in word learning, a finding in line with the predictions of the RHM. Our findings tentatively suggest that this critical mass might be found at a level of at least 40% exposure over the child's lifetime, which is in line with the landmark study by Elin Thordardottir (2011) that showed similar results for vocabulary size.

We also compared performance between the bilingual and monolingual children. Even though their performance differences did not reach statistical significance, it is clear when looking at the box plots in Figure 1 and the scatter plot in Figure 2 that the monolinguals perform in a higher range. With a larger sample, this trend would likely come out significant. This ties in with lower academic performance seen in many bilinguals when attending L2 schools (e.g., OECD, 2010). The current findings suggest that one explanation for lower performance for bilinguals could be that word learning is dependent on cumulative language exposure, and that for some bilingual children L2 schooling is helpful for academic word learning while for others it is not. The findings thus have implications for a discussion on what support can be given to L2

students to increase their academic vocabulary. In general, a positive correlation between total amount of language exposure and word learning performance implies that the more exposure the better. However, our findings also show that the children with and without French in the home performed at similar levels, despite all children being enrolled in French school and thus having little variability in their French school exposure. This indicates that more is not necessarily better but instead points to the importance of type of exposure and within what context. Tentatively, the study shows that by third grade, children do not need L2 in the home to learn new L2 words at school as well as their bilingual peers with L2 in the home. L2 exposure in school is what matters most for academic word learning.

Consequently, if more L2 exposure at home is not helping the children but they are still lagging behind in receptive vocabulary size compared to monolinguals, the question arises: what will help them? Firstly, bilingual children need a high level of L2 exposure, especially in school. Secondly, bilingual input within a learning context can be beneficial for word learning if the child has a low exposure to L2. However, for children with higher levels of L2 exposure, bilingual input might be distracting and they would benefit more from monolingual learning only. To find the point at which bilingual input is helpful or not, one must start off by viewing bilingualism not as a binary factor of being bilingual or monolingual, but rather as being on a bilingual continuum based on the level of exposure and proficiency. Our findings, which are based on a limited sample size at this time and need to be verified with a larger sample, suggest that a critical mass of 40% total language exposure since birth is a point where children no longer will need bilingual input to learn new L2 words (which is supported in previous research on vocabulary, cf. Elin Thordardottir, 2011, Hoff et al., 2012). More research using detailed exposure measures will further our knowledge.

In sum, even though bilingual educational programs can be beneficial for other important reasons (e.g., L1 development, cultural identity, and, possibly, language skills other than lexicon), the exposure to L2 in school matters the most for learning new L2 words. With rich exposure to L2, monolingual input in learning situations is enough for learning; however, without rich exposure, children may be helped by bilingual input.

Limitations and Future Directions

Since the current study is the first of its kind, replications including larger sample sizes of children with a large variety of language backgrounds would be most welcome and might be able to better pinpoint the level of language exposure where children shift to learning more under monolingual conditions. Further, a possible limitation with the design of the experimental task is the very implicit nature of the embedded definitions, making the task too difficult. A recommendation for future studies would be to examine whether having a more explicit link between target word and definitions would enhance performance. Moreover, our study focused on the incidental learning of L2 words and, consequently, did not address the numerous other reasons why including L1 in school is beneficial to bilingual learners, for example strengthening L1 development and cultural identity, to name a few. More research on the topic in relation to word learning is encouraged.

Table 1

Means and standard deviations on background and language experience measures for the bilingual and monolingual children, as well as statistics of group comparisons.

	Bilingual	Monolingual	Group comparisons		
	Mean (SD)	*Mean (SD)*	*t*	*df*	*p*
Age (months)	106.52 (4.10)	105.71 (4.1)	-.62	43	.541
Maternal education (years)	17.80 (2.92)	18.57 (1.83)	.91	42	.370
Non-verbal IQ[1]	109.14 (14.16)	112.36 (14.73)	.69	41	.494
Cumulative language exposure, French	.49 (.30)	.99 (.01)	6.13	43	< .001**
Cumulative language exposure, English	.35 (.28)	.01 (.01)	-4.61	43	< .001**
Language exposure at home, French	.40 (.39)	1.00 (.00)	5.69	43	< .001**
Language exposure at home, English	.41 (.37)	.00 (.00)	-4.04	43	< .001**
Language exposure at school, French	.91 (.13)	.97 (.02)	1.82	43	.075
Language exposure at school, English	.09 (.13)	.03 (.02)	1.7	43	.096
AoA[2], French	19.71 (26.68)	0 (.00)	-2.75	43	.009**
AoA[2], English	18.26 (25.41)	56 (18.31)	4.33	39	< .001**

[1] Measured with Leiter-R
[2] Measured in months
* $p < .05$, ** $p < .01$

Table 2

Descriptive data on performance on the word learning experiment (maximum: 7 points) across groups and experimental conditions. Number of participants is noted for each condition and group.

	Bilingual	Monolingual
	Mean (SD)	*Mean (SD)*
Monolingual condition[1]	1.92 (1.44) *n* = 13	2.86 (1.85) *n* = 14
Bilingual French condition[2]	1.50 (1.20) *n* = 10	-
Bilingual English condition[3]	.56 (.78) *n* = 8	-

[1]The entire task and definitions are presented in French

[2]The text is presented in French with English embedded definitions. Pre- and post-test items are presented in French.

[3]The text is presented in English with French embedded definitions. Pre- and post-test items are presented in English.

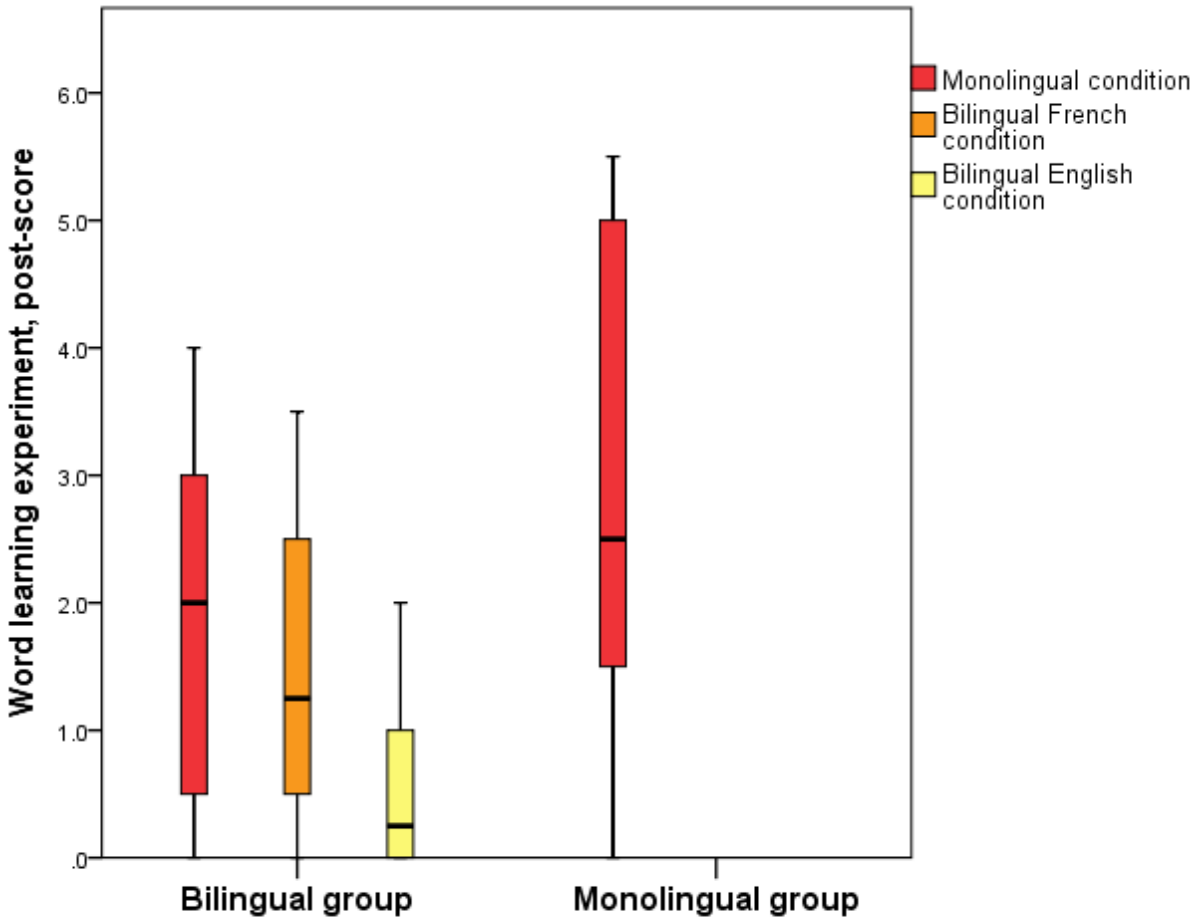

Figure 1

Performance on the word learning experiment (maximum: 7 points), divided by language group and experimental condition.

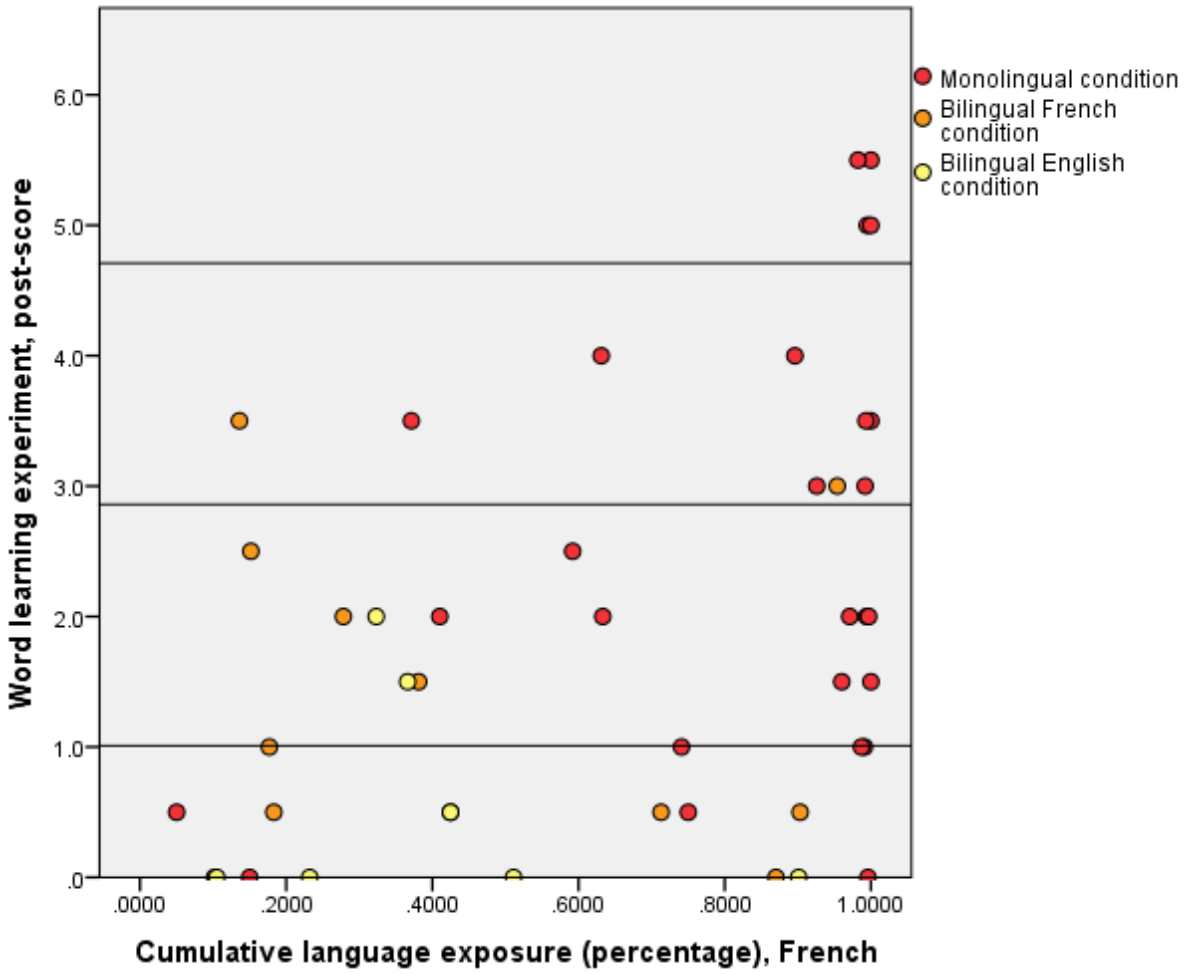

Figure 2

Performance on the word learning task of all children (maximum: 7 points), plotted as a function of total amount of cumulative language exposure to French, with experimental condition assigned to each data point. The monolingual children all have close to 100% French exposure. For comparison to the monolingual performance range, lines have been drawn to show the mean of the monolingual group and +/- 1 standard deviation.

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8. General Discussion and Conclusions

The purpose of the present thesis was to examine depth of vocabulary in bilingual school-age children in relation to their language exposure and age of acquisition (AoA) in French and English. It is known that bilingual children show lower performance in vocabulary breadth compared to monolingual peers when looking at each of their languages separately (e.g., Bialystok et al., 2010; Hammer et al., 2008; Oller & Eilers, 2002; Oller et al., 2007; Pearson et al., 1993) but little is known about bilingual performance on vocabulary depth. The aim was to investigate the mechanisms behind how school-aged bilinguals, educated full-time in an L2 setting, reach their depth of vocabulary as well as the extent to which they are successful in mastering vocabulary depth. The experimental tasks spanned different dimensions of vocabulary depth, and covered both academic and non-academic activities. The first study employed a task of formal word definitions, an academic skill examining the degree of word knowledge and the ability to adhere to formal requirements. The second study examined use of vocabulary by utilizing the task of verbal fluency, word generation under semantic or phonemic constraints. Finally, the third study focused on learning of vocabulary, specifically whether bilingual children learn more with bilingual or monolingual input within an incidental word learning experiment mimicking real-life academic learning. All three studies examined the relationship between performance and language experience factors in detail.

The first main goal was to compare bilingual performance to that of monolingual peers to identify areas of strengths or weaknesses. A striking trend across all three studies was the finding of several areas of strength – tasks where bilinguals performed on par with monolinguals, despite significantly smaller receptive and expressive vocabularies (as reported in Elin Thordardottir, in press). The bilingual children showed no difference on the word definitions task, on the variables

semantic content or linguistic form, or on any of the subject words (everyday, math, science), indicating that both their ability to form definitions as well as their degree of word knowledge is similar to monolingual peers (which is surprising considering their differences on vocabulary breadth). Another area of strength was self-estimated knowledge of word definitions, which was a surprising finding. When asked whether they knew a word, the bilingual children were significantly less confident than their monolingual counterparts. However, they were also more realistic in estimating their abilities, which indicates a stronger ability to self-monitor. We speculated that this might be a consequence of being schooled in your L2, and could also be related to the challenges that face bilingual children in L2 schooling (cf. Donahue et al., 2001; OECD, 2010). The explicit relationship of these factors needs to be researched more in-depth.

For the task of verbal fluency, the comparisons between bilinguals and monolinguals were mixed. A strength was seen on phonemic fluency and switching strategy for the bilingual children; that is, they compensated for a smaller vocabulary and performed on par with monolinguals on these tasks involving executive functioning abilities to a large degree. For the word learning experiment, the results were somewhat inconclusive in that while bilingual and monolingual children showed no significant differences in performance if they were doing the experiment in a monolingual French condition (mimicking how these children were instructed in school), the monolingual children performed in a higher range when looking at average performance. It is likely that this trend could come out significant in a larger sample, and future research could replicate this.

Taken together, the findings show the scope of vocabulary depth tasks is fundamentally different from breadth and imply involvement of other linguistic or cognitive faculties that are not at a disadvantage in bilinguals and are important for academic success. Vocabulary breadth is

strongly tied to explicit exposure of words (He & Arunachalam, 2017; Samuelson & McMurray, 2017) and vocabulary depth is, in turn, tied to breadth, since it is a prerequisite for building depth in the lexicon. But our findings suggest that vocabulary depth also taps into other skills that are of importance for vocabulary learning. Measuring those other skills was beyond the scope of the present work, but, speculatively, involvement can be suggested from several other linguistic or cognitive faculties that are related to vocabulary. The findings on word definitions show that meta-linguistic skills are important as well as semantic network organizations and ability to utilize academic instruction. The findings on phonemic fluency suggest the importance of access to lexical representations, their organization, and level of literacy. Additionally, the findings on the word learning experiment also emphasize the ability to utilize academic (monolingual) instructions. Thus, our findings suggest that all of these factors, in combination with amount of L2 exposure, together contribute to development of L2 vocabulary depth.

However, we also found an area of weakness for the bilingual children on semantic fluency (total words and mean cluster size). This is in line with previous research (Friesen et al., 2015; Kormi-Nouri et al., 2012) and implicates a stronger connection to vocabulary breadth, compared to phonemic fluency. A critical finding was that the difference between bilingual and monolingual groups only occurred in grade 3, not in grade 1. Thus, despite two more years of French schooling, the bilingual children had not improved their semantic fluency whereas the monolingual children had. This is a concerning finding, showing increasing difficulties for the bilingual children and relating to challenges that many bilingual students have in L2 school settings (cf. Donahue et al., 2001; OECD, 2010). Further, Study 2 was the only study that included first-graders, as the other tasks were grade-dependent and would have been too

advanced for the children in grade 1. Accordingly, we cannot compare performance on word definitions or word learning across the grades. This would be recommended for future research.

The second main goal of the thesis was to investigate the effects of language experience variables with our measures of vocabulary depth. The focus was on different types of language exposure as well a division into simultaneous and sequential learners of French to examine effect of AoA. An overall trend found across all three studies was a nonlinearity or threshold effect of exposure, supporting studies on vocabulary breadth (Elin Thordardottir, 2011; Hoff et al., 2012). For word definitions, a stronger relationship was seen in English compared to French. Due to their French schooling, the children had had more French exposure than English exposure. The same pattern was also seen in home versus school exposure, in both languages. Stronger correlations were seen where the children as a group had smaller amounts of exposure, which could be interpreted as an indication that for the larger amounts, a threshold had already been approached. This was valid across the domains of home and school and seen in both French and English, despite the task being an academic task and the children schooled full-time in French. The bilingual children with French at home did not perform better than the children without French, indicating that the amount of French they had been exposed to over four years in school was enough to reach that threshold. It could also point to the context-dependency of exposure for depth of vocabulary, in that school, not home, exposure is what matters for the academic task of word definitions.

Moreover, the findings from the word learning experiment showed that children with less than 40% exposure to French performed below monolingual range. Due to sample size, statistical analyses were not possible on this average difference and more research is needed; however, this might suggest a threshold effect of exposure not only on how much vocabulary is learned but

also affecting under what conditions learning takes place. If L2 exposure is in the lower range, bilingual learning situations might be helpful, while if L2 exposure is in the higher range, bilingual input might be an obstacle to learning. This trend is worth replicating with a larger sample.

To examine the generality of exposure effects, several different measures of language exposure were included. Cumulative amount of exposure showed stronger correlations than current exposure, however neither showed as strong correlations with the depth measures as seen for vocabulary breadth, which highlights how language exposure affects specific skills differently. It also points to the possibility of a smaller effect of exposure on vocabulary depth due to stronger involvement of language abilities that are less dependent on exposure, for example meta-linguistic skills or executive functioning. This ties in well with the discussion above. Moreover, it is possible that accumulated language knowledge is more important than any effect of being actively bilingual or current bilingual experience for vocabulary development. However, as cumulative and current exposure come close in statistical magnitudes, this is presently speculation on our part. More research is needed but, as other studies have shown, our findings show that not only is it necessary to include detailed measures of exposure in research on bilingual language development, it is also of methodological interest to continue examining any discrepant effects of different measures.

The effect of AoA was investigated in Study 1 and 2. Even though it is conventional to divide bilingual children into early (simultaneous) and late (sequential) learners of a language, these studies could find no significant effects on French lexical performance dependent on when the children had started learning French. Simultaneous and sequential children performed on par throughout. In Study 1, AoA was also examined as a continuous variable and a small correlation

was seen with self-estimated knowledge of word definitions. This was also the one measure where bilingual children differed from the monolingual group. Disentangling AoA from amount of exposure is inherently and methodologically challenging and since we found no differences between simultaneous and sequential children, our interpretation is that amount of exposure plays a larger role than AoA. This is in line with recent lexical studies that have examined this distinction more in-depth with focus on breadth of vocabulary (Elin Thordardottir, in press; Unsworth, 2016).

To summarize, the present work emphasizes how fundamentally different vocabulary depth is from breadth and how this may manifest in bilingual school-age children. Importantly, depth of vocabulary involves other linguistic faculties or processes that help bilingual children overcome their smaller vocabulary size in the language in question. Speculatively, this could be meta-linguistic skills, lexical organization, ability to utilize academic instruction, or effect of level of literacy. Further, the relationship between amount of language exposure and vocabulary depth is not as strong as for breadth, again pointing to the involvement of other language faculties. An overall trend in this work was a threshold effect for amount of exposure, a finding in line with previous research (cf. Elin Thordardottir, 2011; Hoff et al., 2012). Further, the main findings have several practical implications for bilingual children schooled in their L2. First, for building vocabulary, rich L2 exposure is needed, as seen on vocabulary breadth measures. However, a way to strengthen lexical performance in school could be to encourage multi-dimensional word learning strategies and building depth of vocabulary, by tapping into areas of strength in bilinguals. This may help compensate for a smaller L2 vocabulary. Further, exposure ought to be targeted on the skills that build depth of vocabulary, and not just on exposure to a variety of L2 words. Like previous research, our studies show that more exposure is not

necessarily better. At later primary grades, it seems likely that instead of amount of exposure, the target of exposure will matter more. Further, not just the quality and detail of word knowledge exposure will matter, but also the teaching of strategies and skills. Importantly, the bilingual children in our sample did not perform differently if they had French in the home or not, suggesting that bilingual families can focus on the language of their choice in the home, without concern for vocabulary depth in school.

Finally, in conclusion, it is well known that exposure is key for development of vocabulary and research shows that for breadth of vocabulary in bilinguals, amount of exposure is vital up until a certain point, after which more is not necessarily better. The present work shows that this appears true for depth of vocabulary as well, albeit the connection seems weaker. However, we also show that after that point has been reached, the importance of quality might exceed quantity of exposure.

8.1 Limitations and Future Directions

The present thesis included bilingual children educated full-time in their L2, which is the norm for bilingual children. However, doing similar research on children educated in bilingual programs would offer important insights. Similarly, the studies focused on French for the participating French-English bilinguals. Future work should involve French-English bilinguals that are attending English schools, and compare with monolingual English-speaking children. One of the advantages of including French-English bilinguals in Montreal, as was the context for the current work, is that the two languages have similar socio-economic status. However, research on language pairs with discrepant status would offer insights as well.

Furthermore, the thesis offered an in-depth examination of the effect of language experience. Future research should look at other possible predictors of the tasks employed in this

work. A trend in this work was a threshold effect of exposure. However, examining adapted versions of word definitions and the word learning experiment in younger children will enable a narrowing in on that threshold for the tasks in question. Likewise, including older children will offer insights for the verbal fluency task and whether the gap between bilingual and monolingual children will continue to increase.

The word learning experiment came to a tentative conclusion that children with low exposure would benefit from bilingual input in incidental word learning. This would have important implications for educational settings, however, the results need to be replicated with a larger sample to be able to conduct robust statistical analyses. Learning of L2 words in school is a cornerstone of academic success, warranting further research.

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10. Appendices

Appendix A

WORD DEFINITION TASK

Name: _____

Test date:_____ Examiner: _____

Instructions: "*Now we are going to talk about words.* (give demonstration items and offer feedback, when the child understands the task, move on to item 1) *Do you know what X means?* (circle Y or N) *What is X?* (transcribe) *Tell me more about X.* (transcribe)"

	Item	Know the word?	Child's response	Score: form	Score: content
Demo	*dog*	-------		-------	-------
Demo	*ice cream*	-------		-------	-------
1	calendar	Y / N			
2	audience	Y / N			
3	probability	Y / N			
4	hero	Y / N			
5	graph	Y / N			
6	reptile	Y / N			
7	statue	Y / N			
8	cube	Y / N			
9	vaporization	Y / N			

10	mammal	Y / N			
11	gravity	Y / N			
12	symmetry	Y / N			
13	denominator	Y / N			
14	undulation	Y / N			
15	carnivore	Y / N			
16	election	Y / N			
17	authentic	Y / N			
18	outcome	Y / N			
19	trapezoid	Y / N			
20	diversity	Y / N			
21	cumulative	Y / N			
22	density	Y / N			
23	buoyancy	Y / N			
24	discrimination	Y / N			
Total scores:		_____		_____	_____

Appendix B

The target text for the word learning experiment presented in manuscript 3. The text is presented for the three different conditions: 1) Monolingual French, 2) Bilingual French, and 3) Bilingual English. For clarification, target words are **bolded** and embedded definitions are underlined.

Monolingual French

Depuis des milliers d'années, les êtres humains ont été capables de franchir toutes sortes d'obstacles tels, que les cours d'eau et les ravins grâce aux ponts. Les premiers ponts étaient très simples : deux ou trois troncs d'arbres couchés en travers d'un ruisseau pouvaient répondre à la demande.

Évidemment lorsqu'il s'agit de traverser des cours d'eau plus larges, les arbres ne suffisent plus. Des architectes inventifs ont donc imaginé de soutenir la structure des ponts au moyen de blocs de pierre appelés **piles** qui étaient solidement posées au fond des cours d'eau. Des **piles** sont des blocs de pierre ou de béton qui supportent les arcs d'un pont.

Bien qu'elle soit très efficace, l'utilisation des piles posait certains problèmes. Tout d'abord, en plaçant les piles dans un cours d'eau, on empêchait les gros bateaux de passer. Ensuite, si le cours d'eau ou le ravin était très profond, il devenait tout simplement impossible d'installer les piles! Une autre structure de support souvent utilisée est la **poutre**. Une **poutre** est une grande barre en fer ou en acier.

Il fallait donc trouver une autre façon de construire des ponts afin que la distance entre deux piles, la **travée**, soit la plus longue possible. La **travée** est l'espace entre les piles d'un pont. De plus, les matériaux utilisés devaient être assez solides pour construire de tels ponts. Le pont **cantilever** à structure d'acier pouvait satisfaire à ces exigences. Un **cantilever** est une longue barre d'acier attachée a un bout et libre à l'autre.

Pour comprendre Pour comprendre comment fonctionne un pont cantilever, imagine deux tremplins de piscine qui se font face et qu'on relie l'un à l'autre. Pour supporter le pont cantilever davantage, les ingénieurs utilisent souvent des **treillis**. Un **treillis** est une structure de support faite de plus petits morceaux assemblés en formes.

Le pont cantilever appelé Pont de Québec a été construit en 1917 et mesure 550 mètres de longueur. Les ingénieurs de l'époque ont dû surmonter de nombreux obstacles pour le construire : le pont est tombé à deux reprises dans le fleuve Saint-Laurent avant d'être achevé.

On a dû utiliser du nickel en combinaison avec d'autres métaux, c'est-à-dire un **alliage**. Un **alliage** est ce qu'on obtient en mélangeant deux ou plusieurs métaux ensemble.

Cet alliage de nickel a dû être utilisé pour diminuer les effets de la corrosion sur la structure d'acier. Quand vint le temps de peindre le Pont de Québec, 56 825 litres de peinture on été nécessaires pour en appliquer une seule couche.

L'autre célèbre pont de type cantilever se trouve à Montréal. C'est le pont Jacques-Cartier qui a été **inauguré**, c'est-à-dire prêt à être utilisé, en 1930. **Inaugurer** quelque chose signifie commencer à l'utiliser. On raconte que dans l'une de ses piles, se trouve une pierre creuse qui recèle toutes sortes d'objets de valeur. Malheureusement, personne ne se rappelle où cette pierre a été placée !

Bilingual French

Depuis des milliers d'années, les êtres humains ont été capables de franchir toutes sortes d'obstacles tels, que les cours d'eau et les ravins grâce aux ponts. Les premiers ponts étaient très simples : deux ou trois troncs d'arbres couchés en travers d'un ruisseau pouvaient répondre à la demande.

Évidemment lorsqu'il s'agit de traverser des cours d'eau plus larges, les arbres ne suffisent plus. Des architectes inventifs ont donc imaginé de soutenir la structure des ponts au moyen de blocs de pierre appelés **piles** qui étaient solidement posées au fond des cours d'eau. **Pylons** are blocks of stone or concrete that support the arches of a bridge.

Bien qu'elle soit très efficace, l'utilisation des piles posait certains problèmes. Tout d'abord, en plaçant les piles dans un cours d'eau, on empêchait les gros bateaux de passer. Ensuite, si le cours d'eau ou le ravin était très profond, il devenait tout simplement impossible d'installer les piles! Une autre structure de support souvent utilisée est la **poutre**. A **girder** is a large iron or steel beam.

Il fallait donc trouver une autre façon de construire des ponts afin que la distance entre deux piles, la **travée**, soit la plus longue possible. A **span** is the space from one point to another. De plus, les matériaux utilisés devaient être assez solides pour construire de tels ponts. Le pont **cantilever** à structure d'acier pouvait satisfaire à ces exigences. A **cantilever** is a long beam fixed at one end and free at the other.

Pour comprendre Pour comprendre comment fonctionne un pont cantilever, imagine deux tremplins de piscine qui se font face et qu'on relie l'un à l'autre. Pour supporter le pont cantilever davantage, les ingénieurs utilisent souvent des **treillis**. A **truss** is a supportive structure made up of smaller parts built in triangular shapes.

Le pont cantilever appelé Pont de Québec a été construit en 1917 et mesure 550 mètres de longueur. Les ingénieurs de l'époque ont dû surmonter de nombreux obstacles pour le construire : le pont est tombé à deux reprises dans le fleuve Saint-Laurent avant d'être achevé. On a dû utiliser du nickel en combinaison avec d'autres métaux, c'est-à-dire un **alliage**. **Alloy** is what you get when mixing two or metals together.

Cet alliage de nickel a dû être utilisé pour diminuer les effets de la corrosion sur la structure d'acier. Quand vint le temps de peindre le Pont de Québec, 56 825 litres de peinture on été nécessaires pour en appliquer une seule couche.

L'autre célèbre pont de type cantilever se trouve à Montréal. C'est le pont Jacques-Cartier qui a été **inauguré**, c'est-à-dire prêt à être utilisé, en 1930. To **inaugurate** means to put something into use. On raconte que dans l'une de ses piles, se trouve une pierre creuse qui recèle toutes sortes d'objets de valeur. Malheureusement, personne ne se rappelle où cette pierre a été placée !

Bilingual English

For thousands of years, people have been able to get across all kinds of obstacles, such as waterways and ravines, thanks to bridges. The earliest bridges were very simple: two or three tree trunks laid across a stream could solve the problem.

Of course, trees are not enough when it comes to crossing much larger waterways. Inventive architects came up with the idea of supporting bridge structures using stone blocks called **pylons** that were firmly implanted at the bottom of waterways. Des **piles** sont des blocs de pierre ou de béton qui supportent les arcs d'un pont.

While very efficient, the use of pylons has its drawbacks. First, placing the pylons in the waterway prevents the passage of large ships. Also, if the waterway or ravine is too deep, it is impossible to install the pylons! Another support structure often used is **girders**. Une **poutre** est une grande barre en fer ou en acier.

Consequently, another way had to be found to build bridges so that the distance between the two pylons, the **span**, could be as long as possible. La **travée** est l'espace entre les piles d'un pont. As well, the materials used had to be strong enough to build these bridges. A steel structure called **cantilever** met these requirements. Un **cantilever** est une longue barre d'acier attachée a un bout et libre à l'autre.

To understand how a cantilever bridge works, imagine two diving boards facing each other and attached end-to-end. To support the cantilever bridge further, engineers often use **trusses**. Un **treillis** est une structure de support faite de plus petits morceaux assemblés en formes triangulaires.

The cantilever bridge called Pont de Quebec was built in 1917 and measures 550 m in length. The engineers at the time had to overcome a number of obstacles to build it. The bridge collapsed twice into the St. Lawrence River before it finally held fast. They used nickel in combination with other metals, called an **alloy**. Un **alliage** est ce qu'on obtient en mélangeant deux ou plusieurs métaux ensemble.

This nickel alloy had to be used to reduce the destruction caused by corrosion on the steel structure. When it came time to paint the Pont de Quebec, 56 825 L of paint were needed for a single coat!

Another famous cantilever bridge is located in Montreal. It is called the Pont Jacques-Cartier and was **inaugurated**, meaning it was ready to be used, in 1930. **Inaugurer** quelque chose signifie commencer à l'utiliser. Apparently, one of the pylons houses a hollow rock containing all kinds of valuable objects. Unfortunately, no one remembers where this rock was placed!