Early vocabulary development in very young French-English bilinguals: A longitudinal study

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Abstract

Early vocabulary development in very young French-English bilinguals:
A longitudinal study

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The present dissertation had three main goals: 1) To examine similarities and differences in monolingual and bilingual vocabulary acquisition during a critical period of development 2) To examine how processing speed and language exposure differentially impact vocabulary development and the acquisition of translation equivalents (TEs; words in each language that mean the same thing, such as *dog* in English and *chien* in French) in bilingual children during the second year of life, and 3) To acquire a more comprehensive understanding of the stability and continuity of early bilingual vocabulary development by using a direct measure of vocabulary comprehension and processing speed (the Computerized Comprehension Task; CCT) in conjunction with parent reported vocabulary (the MacArthur Bates Communicative Development Inventory; CDI) longitudinally. In order to address these goals, data was collected on two samples of children, one monolingual and one bilingual, at three different developmental time points. Three manuscripts were then written based on this data, and are included as part of this dissertation.

The first manuscript, published in 2016 in the *Journal of Child Language*, examines the receptive vocabulary development of a sample of French-English bilingual and French monolingual children at 16 months of age. This manuscript not only

compares the bilingual sample's receptive vocabulary development and word processing speed to that of their monolingual peers using data from the CCT and CDI, but it also examines the emergence of TE acquisition, and investigates within- and cross-language relations between vocabulary size and reaction time (RT). The findings from this paper suggest that bilingual receptive vocabulary development is largely on par with that of monolingual development, and that learning more than one language from birth does not hinder children's speed of lexical access. Importantly, it also emphasizes the link between language exposure, vocabulary size, and processing speed, and shows that children with larger vocabularies tend to be faster at processing words.

The second manuscript included in this dissertation was published in *Bilingualism: Language and Cognition* in 2016. It follows the same samples of children from 16 to 22 months of age, and focuses on growth in vocabulary *comprehension* and *production*, as well as changes in language exposure and processing speed across waves. Importantly, this study is the first to investigate vocabulary growth in a sample of French–English bilingual toddlers using a *longitudinal design* in conjunction with a *direct measure* of vocabulary development. Although both receptive and expressive vocabulary development began slowly in the bilingual sample with learning divided across languages, over time these toddlers acquired approximately as many new words as their monolingual peers in their dominant language, and exhibited a total vocabulary size that was equivalent to, or larger than, their monolingual peers. Furthermore, children's processing speed increased across waves, and RT on the CCT at 16 months emerged as a significant predictor of receptive vocabulary size at 22 months for the bilinguals. Importantly, both within- and cross-language relations emerged between language

exposure, vocabulary size, and processing speed for the bilinguals, once again emphasizing the complex interplay between these variables early on in development.

Finally, the third manuscript included in the present dissertation was published in the *Journal of Child Language* in 2017. It focuses on productive vocabulary development and the acquisition of TEs in our French-English bilingual sample across three developmental time points, at 16, 22, and 30 months. It also compares a direct measure of TE development with parent report in a separate sample of 24-month-old French-English bilinguals. This is the first study to longitudinally investigate the impact that changes in language exposure and vocabulary size have on TE development during the second and third years of life. It is also the first study to compare a direct measure of TE comprehension with parent report during the second year of life. This manuscript shows that the acquisition of TEs is a gradual process that begins early on in bilingual development. It also provides evidence for the relation between quantity of language exposure and TE development, but shows that the ratio of L1 (dominant) to L2 (non-dominant) vocabulary is a better predictor of TE development than L2 exposure alone in young bilinguals. Lastly, this manuscript emphasizes the importance of using both direct and indirect measures of early vocabulary comprehension and TE development, as it shows that parents of bilingual children may have a tendency to over-report their child's receptive word knowledge when completing vocabulary checklists.

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First, I would like to thank my research supervisor, Dr. Diane Poulin-Dubois, whose dedication and enthusiasm for research has inspired and motivated me throughout the process of completing this dissertation. She has been a source of guidance and knowledge throughout my studies, and her support is greatly appreciated.

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This research was also supported by grants from the National Institute of Health and Child Development (NIHCD) to Dr. Diane Poulin-Dubois. I have personally been supported by the Fonds de Recherche du Québec: Société et Culture (FQRSC), as well as the Faculty of Arts & Science Graduate Fellowship from Concordia University.

Contribution of Authors

This Ph.D. consists of three manuscripts:

Manuscript 1 (see Chapter 2)

Legacy, J., Zesiger, P., Friend, M. & Poulin-Dubois, D. (2016). Vocabulary size, translation equivalents, and efficiency in word recognition in very young bilinguals. *Journal of Child Language*, 43(4), 760–783.

Manuscript 2 (see Chapter 3)

Legacy, J., Zesiger, P., Friend, M. & Poulin-Dubois, D. (2016). Vocabulary size and speed of word recognition in very young French-English bilinguals: A longitudinal study. *Bilingualism: Language and Cognition*. DOI: https://doi.org/10.1017/S1366728916000833

Manuscript 3 (see Chapter 4)

Legacy, J., Reider, J., Crivello, C., Kuzyk, O., Friend, M., Zesiger, P. & Poulin-Dubois, D. (2017). Dog or chien? Translation equivalents in the receptive and expressive vocabularies of young French-English bilinguals. *Journal of Child Language*, 44(4), 881–904.

Relative Contributions

I tested participants as a secondary experimenter across all three waves of data collection. I was responsible for coding, data entry, statistical analysis, and interpretation of all results. I was also in charge of preparing and revising the three manuscripts that are included in this dissertation. For each manuscript, I wrote the first draft, and Dr. Diane Poulin-Dubois, as well as our collaborators, Dr. Margaret Friend and Dr. Pascal Zesiger, provided feedback. As part of knowledge translation efforts in the Cognitive and Language Development Laboratory, a summary of the results of each study was also sent to the participating families via a biannual newsletter.

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CHAPTER 1

General Introduction

The advent of globalization has resulted in bilingualism being the norm rather than the exception in most societies (Blommaert, 2010). More children are growing up bilingual than ever before, however, there is still much that is unknown regarding how bilinguals acquire each of their languages in comparison to monolinguals. Although research on bilingualism has increased in recent years, there are many gaps in the literature with respect to how bilingual children acquire their lexicons, and how cognitive and environmental factors, such as processing speed and language exposure, impact early vocabulary development in each of the languages acquired by these children. Furthermore, similar to the monolingual literature, a great deal of emphasis has been placed on vocabulary *production* rather than vocabulary *comprehension* within the bilingualism research literature. Importantly, vocabulary comprehension is an aspect of early language development that has historically been neglected in the literature due to a myriad of methodological difficulties. This especially seems to be the case for very young children, with the majority of studies to date relying on parent report measures of infant and toddler vocabulary comprehension. Although vocabulary checklists, such as the MacArthur Bates Communicative Development Inventory (CDI), have been established as an easy, convenient, and fairly accurate method of estimating vocabulary comprehension in young children, these measures are also susceptible to the bias and error that are inherent in any self-report tool (Law & Roy, 2008). Moreover, there is research to suggest that parents of bilingual children may have a more difficult time accurately reporting on their child's comprehension in each of their developing languages (Lust et al., 2014; Pearson, Fernández & Oller, 1995). This makes studies incorporating direct measures of early vocabulary development crucial to our understanding of early bilingual language acquisition. Yet, despite this need for complementary direct measures of vocabulary development in the literature, studies incorporating direct measures during the second

year of life are quite rare. Furthermore, there are very few *longitudinal* studies incorporating direct measures of vocabulary development in the bilingualism literature; a gap that we aimed to address via the Path to Literacy Project.

The Path to Literacy Project is a multisite, longitudinal research project that is composed of six waves of data collection beginning at 16 months of age. It is focused on relating the early stages of receptive and expressive vocabulary development to later school readiness and literacy skills in monolingual and bilingual children. The first two waves of the study aimed to provide a better understanding of early monolingual and bilingual language development by utilizing a *direct* measure of vocabulary comprehension in conjunction with parent reported receptive and expressive vocabulary. The Computerized Comprehension Task (CCT) is a touch-screen measure of early vocabulary comprehension that has been designed for children 16-24 months of age. Created by Friend and Keplinger (2003), this touch screen computer game has been shown to be effective in eliciting and maintaining attention and motivation in toddlers. Whereas preferential looking paradigms have been established as an effective method for investigating language comprehension in infants as young as 4-months (Golinkoff, Ma, Song & Hirsh-Pasek, 2013), such methods are less appropriate for older children, which makes picture selection methods, such as the CCT, preferable for directly examining vocabulary comprehension during the second year (Friend & Keplinger, 2003). Importantly, although the CCT has previously been found to provide valid and reliable estimates of vocabulary comprehension and word processing speed in monolingual language learners (Friend & Keplinger, 2008), when the Path to Literacy Project began, it had yet to be tested with a bilingual population. As a result, a main goal of the Path to Literacy Project, and indeed this dissertation, was to measure vocabulary comprehension and word processing speed in a sample of 16-month-old *bilingual* children, and compare their

performance on the CCT to that of a monolingual sample of children. Moreover, by using the CCT in conjunction with parent reported receptive and expressive vocabulary at two different time points (children were tested at 16 months and again at 22 months), it was possible to examine the convergent validity and continuity of receptive vocabulary over time in these samples of children. Although data collection is ongoing at several different sites, including Concordia University (French-English bilinguals), San Diego State University (Spanish and English monolinguals; Spanish-English bilinguals), the University of Geneva (French monolinguals), and Universidad Nacional Autónoma de México (Spanish monolinguals), this dissertation focuses on the first three waves of the larger Path to Literacy Project, and investigates the utility of the CCT within a bilingual sample of children.

Early bilingual vocabulary development

There is a great deal of research showing that early bilingual vocabulary development is, in many ways, very similar to that of monolingual vocabulary development. Bilingual children have been shown to speak their first words around 12 months of age, and to begin to combine words together around 18 months of age, just as monolingual children do (Genesee, 2003; Genesee & Nicoladis, 2007; Patterson & Pearson, 2004; Pearson, Fernández & Oller, 1993). However, research also shows that a bilingual language learner is not the equivalent of two monolingual language learners. With a limited number of waking hours devoted to language learning each day, bilingual children must divide this time, and ultimately their learning, across each of their respective languages. In fact, it has been shown that the number of words learned by bilinguals in each of their languages is directly proportional to the average amount of time that they are exposed to each of their languages (Hoff & Core, 2013; Hoff, Core, Place, Rumiche, Señor & Parra, 2012; Hoff, Rumiche, Burridge, Ribot & Welsh, 2014; Pearson,

Fernández, Lewedag & Oller, 1997). However, given that a bilingual language learner is not, in essence, two monolinguals in one, the following questions remain: i) to what extent does bilingual vocabulary development differ from monolingual development; and ii) do children acquiring more than one language from birth learn new words at the same rate as their monolingual peers?

In response to this first question, it would appear that, in general, bilingual children tend to have slightly smaller receptive and expressive vocabularies in each of their individual languages than monolingual children do (Core, Hoff, Rumiche, & Señor, 2013; Hoff et al., 2014; Pearson et al., 1993). However, they also tend to have a total vocabulary size that is on par with, or larger than, their monolingual peers (Core et al., 2013; Hoff et al., 2012; Junker & Stockman, 2002; Pearson et al., 1993). This suggests that although bilinguals might not comprehend or produce as many words as their monolingual peers when only one of their languages is considered, the total number of words learned in both languages combined is typically comparable or superior to that of children learning only one language.

These findings, of course, are relevant to the second question posed above, as they suggest that bilingual children learn new words at the same rate as, or perhaps faster than, monolinguals. Although individual growth trajectories for bilingual children have been shown to be dependent on a number of individual (e.g., the languages being learned, processing speed; Hoff et al., 2014; Hurtado, Grüter, Marchman & Fernald, 2014; Marchman, Fernald & Hurtado, 2010) and environmental factors (e.g., quantity and quality of input; Hoff & Core, 2013; Hoff & Core, 2015; Hoff et al., 2012; Hoff et al., 2014; Pearson et al., 1997), both monolingual and bilingual children have been shown to exhibit fairly linear patterns of vocabulary growth over time, with the exception of an accelerated period of growth early on in development (Goldfield

& Reznick, 1990; Kan & Kohnert, 2012; Pearson & Fernández, 1994; Vagh, Pan & Mancilla-Martinez, 2009). Moreover, word learning studies with monolingual and bilingual children suggest that on average, bilingual children are just as capable of learning new words as their monolingual peers (Byers-Heinlein, Fennell & Werker, 2013; Kan & Kohnert, 2012), with only minor differences in perceptual abilities observed early on in development (Werker & Byers-Heinlein, 2008).

Translation equivalents

Interestingly, when it comes to early vocabulary development, bilingual children face additional challenges that monolingual children do not. Bilingual children's acquisition of translation equivalents (TEs; words in each language that mean the same thing, such as *dog* in English and *chien* in French) for example, violates the mutual exclusivity bias that has been shown to be present in monolinguals (Byers-Heinlein & Werker, 2009). This tendency to only accept one label for a given object is a word learning heuristic that emerges early on in monolingual development to help children quickly expand their emerging lexicons. However, bilingual children rapidly learn that an object *can* indeed have more than one label, leading most children to acquire at least some TEs in their vocabulary by the end of the second year (30% on average; Bosch & Ramon-Casas, 2014; David & Wei, 2008; Pearson et al., 1995; Poulin-Dubois, Bialystok, Blaye, Polonia & Yott, 2013; Poulin-Dubois, Blaye, Coutya & Bialystok, 2011). Whereas there is evidence to suggest that children who are raised in environments that are more conducive to balanced language acquisition tend to acquire a greater proportion of TEs early on in development (David & Wei, 2008; Montanari, 2010; Pearson et al., 1995; Poulin-Dubois et al., 2013), there are also studies showing that quantity of exposure to one's second language is a poor predictor of how many TEs a child has in their vocabulary (Byers-Heinlein & Werker,

2013; Lanvers, 1999). Of note is the fact that although there is a great deal of individual variability in the proportion of TEs that a child acquires, it is known that TE acquisition generally increases over time in relation to children's vocabulary production (Montanari, 2010). Importantly, a main goal of this dissertation was to examine potential predictors of TE development from 16 to 30 months, in the form of changes in relative language exposure and vocabulary size. By investigating the relative role that each of these factors might play in the acquisition of TEs, we were able to help clarify some of the inconsistencies in the bilingualism literature on TE development in very young children.

Interestingly, the emergence of TEs during this critical period also indicates that bilingual children are able to differentiate their language systems very early on in development. As a result, one might wonder how vocabulary development in the child's dominant language (L1) impacts vocabulary development in their non-dominant language (L2), and vice versa. Interestingly, previous cross-sectional studies examining cross-language relationships in the receptive and expressive vocabularies of bilinguals have found weak or absent links across languages, suggesting that vocabulary growth in a child's L1 does not always directly predict vocabulary growth in L2 (Kan & Kohnert, 2008; Marchman et al., 2010). However, a recent study using a dynamic measure of vocabulary development did in fact find cross-language relationships between children's L1 and L2 vocabulary development (Kan & Kohnert, 2012). Given these mixed findings, and a lack of longitudinal studies examining cross-language relations in the literature, a main goal of this dissertation was to examine how vocabulary development in L1 impacts vocabulary development in L2 across two developmental time points. By examining these cross-language relations, this dissertation will provide a more

complete understanding of the bi-directionality of early vocabulary acquisition during a critical period of development.

Factors predicting early vocabulary development

There are numerous factors that have been shown to predict early vocabulary development in the literature. Some of these factors, such as processing speed, are internal, and come from within the child. Others, however, are external in nature, and are associated with the learning environment that the child grows up in. This dissertation will focus on two factors that have emerged as important predictors of vocabulary growth in the bilingualism literature: *processing speed* and *language exposure*.

Processing speed. Recent research with very young children has shown that lexical access, or the speed with which words are retrieved from memory, is directly related to vocabulary size. In essence, this finding suggests the rate at which a child is able to learn new words is not only dependent upon their ability to attend to, segment, and infer information from continuous speech in their immediate environment. It is also heavily reliant on their ability to make connections between new and existing lexical items within their emerging semantic networks. As children acquire new words, it is possible that semantic connections between words are refined and clarified, facilitating retrieval of words from memory, and ultimately enabling additional vocabulary growth (De Anda, Poulin-Dubois, Zesiger & Friend, 2016).

Importantly, the majority of research to date examining the relation between monolingual and bilingual children's processing speed and vocabulary development has utilized the Looking-while-Listening (LWL) paradigm. This is a looking time task that involves tracking infants' eye gaze as they are prompted to attend to a familiar target image on screen. These studies, when conducted with English monolingual infants and toddlers, have established that both existing

vocabulary and processing speed work in conjunction with one another to facilitate word learning. That is, efficiency in word recognition at both 15 and 18 months was positively correlated with accelerated vocabulary growth over the following year (Fernald & Marchman, 2012; Fernald, Marchman & Weisleder, 2013; Fernald, Perfors & Marchman, 2006). Importantly, these longitudinal data also suggest that although children increase their word processing speed over time, there is a fair amount of stability in children's reaction times (RT) and accuracy levels across development (Fernald, Perfors & Marchman, 2006).

Interestingly, similar patterns of development have been observed for 30-month-old Spanish-English bilingual children using the LWL task, with no differences observed between processing speed in L1 and processing speed in L2 (Marchman et al., 2010). Furthermore, although significant within-language relations were observed between vocabulary size and processing speed in this sample of children, no cross-language relations were observed for the bilinguals using the LWL procedure. The fact that speed of processing in English was found to be unrelated to speed of processing in Spanish has important implications regarding the notion of cross-language transfer, and suggests that children's ability in one language has little influence over their ability in their other language. However, it is important to note that Marchman et al. (2010) did not examine these relations according to children's dominant and non-dominant languages, and instead examined cross-language transfer according to the languages being learnt by the children in their study: Spanish and English. Moreover, the observation that there is a lack of cross-language transfer for bilinguals with respect to vocabulary and processing speed is in contrast to findings from cross-language priming studies, which have shown that children primed with semantically related words in their dominant language respond faster to target words in their non-dominant language (Singh, 2014). Moreover, although cross-language relations were not

observed for this sample of bilingual children in the third year of life, our knowledge remains limited regarding the relation between vocabulary size and processing speed in L1 and L2 during the second year, which is typically a period of accelerated vocabulary growth for most children. As a result, this dissertation will aim to address this gap in the literature by extending Marchman et al.'s findings to a younger sample of bilingual children. Moreover, by using a touch screen measure of receptive vocabulary and processing speed and identifying relations between children's *dominant* and *non-dominant* languages, it will also be possible to examine whether the previously observed set of findings can be replicated using an experimental procedure other than the LWL paradigm.

Language exposure. Another factor that has been established as having a significant impact on vocabulary development is language exposure. A large literature has now established the link between language exposure and receptive and expressive vocabulary size in monolingual language learners (Hoff, 2003; Hoff, 2006; Hoff, 2009), and more recently, a significant literature has emerged investigating the impact of language exposure on bilingual vocabulary development (Hoff, 2009; Hoff et al., 2012; Parra, Hoff & Core, 2011). However, although both lines of research show that vocabulary development is typically proportional to the amount of time that a child is exposed to a given language, the bilingualism literature is much more complex, as children are rarely equally exposed to the languages that they are learning (De Houwer, 2007; Hoff & Core, 2013; Hoff & Core, 2015; Hoff et al., 2012; Hoff et al., 2014; Pearson et al., 1997; Poulin-Dubois et al., 2013). As a result, the remainder of this section will review the language exposure literature as it relates to young *bilingual* children.

For bilingual toddlers and children, the relation between language exposure and vocabulary is not always clear-cut. According to the monolingual research literature, there is a

linear relationship between the quantity of input that a child hears and their vocabulary size (Hoff, 2006). Thus, for bilingual children, balanced exposure to two languages should *presumably* result in balanced rates of vocabulary acquisition and balanced vocabulary sizes in each language. However, most bilingual children are not equally exposed to the languages that they hear (De Houwer, 2007; Hoff, 2013), and those that are equally exposed do not always exhibit vocabularies of the same size in each of their languages (Hoff, 2014; Hoff & Core, 2015). Recent research suggests that generally speaking, strategies such as the one-parent-one-language rule do not provide children with balanced rates of exposure to each language (De Houwer, 2007). The language preference of the child, the relative majority status of the languages, and individual differences in the quality and amount of input each parent typically provides for the child all contribute to uneven patterns of exposure (Hammer, Hoff, Uchikoshi, Gillanders, Castro & Sandilos, 2014). These differences in language exposure typically result in children keeping pace with monolingual language learners in their L1, but over time experiencing slower vocabulary development in their L2 (MacLeod, Fabiano-Smith, Boegner-Page & Fontolliet, 2013).

The relation between quantity and quality of language exposure. Importantly, there is now research to suggest that this trade off that is typically observed between L1 and L2 vocabulary growth in bilinguals is greatly dependent on the languages being learnt by a given child. In their work with Spanish-English bilinguals growing up in southern Florida, Erika Hoff and colleagues have been able to show that "not all bilinguals are created equal". In essence, they suggest that every bilingual child has a unique set of environmental circumstances impacting their language development, but that it is the *quality* rather than the *quantity* of input that matters most to young children learning more than one language (Hammer et al., 2014; Hoff et al., 2012;

Hoff et al., 2014). In particular, it has been found that exposure to non-native input (which is characterized by fewer word types, shorter utterances, and a less complex grammatical structure) typically results in children developing much smaller vocabularies than what would be expected given their overall level of exposure to that language (Hoff et al., 2012; Hoff et al., 2014; Place & Hoff, 2011). Although many bilinguals grow up with native input in each of their languages, these results suggest that any type of variation in the quality of input a child hears may have an impact on their rate of vocabulary growth. This is an important finding that not only provides us with additional insight into the external factors influencing bilingual vocabulary development, but also provides us with important information regarding the utility of measures of language exposure *quantity* in predicting vocabulary development. Indeed, there have been inconsistencies in the literature regarding the relation between language exposure, vocabulary size, and processing speed, with some studies finding strong links between these variables, and others not. However, in a recent publication by Grüter and colleagues (2014), it was suggested that inconsistencies in the literature might be due to variations in the use of absolute and relative test scores. As such, they recommended that this problem could potentially be addressed through consistent use of relative variables. Because relative measures, such as the proportion of language exposure, do not account for variations in the *quality* of input that children hear in each language, it is often the case that correlations between language exposure and raw scores on vocabulary tasks are weak at best. However, by comparing *ratios* of language exposure to *ratios* of vocabulary size across languages, some of this additional variance is accounted for, strengthening correlations between these variables. Indeed, in a subsequent manuscript published by the same set of authors, robust correlations were observed between language exposure, vocabulary size, and processing speed when relative variables were used (Hurtado, Grüter,

Marchman & Fernald, 2014). As a result, relative variables were used in manuscripts two and three of this dissertation in order to provide more accurate estimates of the relations between language exposure, vocabulary size, and processing speed.

Goals of the dissertation

Given that bilingualism is a phenomenon that has become more and more prevalent in recent years, research on the factors that influence vocabulary growth in this population is crucial. Research on bilingual language acquisition is not only vital to our understanding of how bilingual children go about learning their languages, but it is also critical to the development of policies related to education and clinical intervention. This introduction to the bilingualism literature has identified a number of important gaps in the literature that must be addressed in order to clarify the developmental path that bilingual children take to learn language. Given these various gaps in the literature, the goals of this dissertation were threefold: 1) To examine similarities and differences in monolingual and bilingual vocabulary acquisition during a critical period of development using a longitudinal design, 2) To examine how both processing speed and language exposure differentially impact vocabulary development and the acquisition of TEs in bilingual children during the second year of life, and 3) To acquire a more comprehensive understanding of the stability and continuity of early bilingual vocabulary development by using a direct measure of vocabulary comprehension and processing speed in conjunction with parent reported vocabulary.

In order to address these goals, three manuscripts published or in press are included in this dissertation. The first manuscript, published in 2016 in the *Journal of Child Language*, examines the receptive vocabulary development of a sample of French-English bilingual and French monolingual children at 16 months of age. This manuscript not only compares the

bilingual sample's receptive vocabulary development and word processing speed to that of their monolingual peers using data from the CCT and CDI, but it also examines the emergence of TE acquisition, and investigates within- and cross-language relations between vocabulary size and RT. The second manuscript included in this dissertation is in press and has been accepted for publication in *Bilingualism: Language and Cognition*. It follows the same samples of children from 16 to 22 months of age, and focuses on growth in vocabulary comprehension and production, as well as changes in processing speed across waves. Importantly, this manuscript examined the relation between relative language exposure, relative vocabulary size, and relative processing speed at each developmental time point, and investigated predictors of receptive and expressive vocabulary growth across this six-month period. Finally, the third manuscript included in the present dissertation is in press and has been accepted for publication in the *Journal of Child Language*. It focuses on productive vocabulary development and the acquisition of TEs in our French-English bilingual sample across three developmental time points, at 16, 22, and 30 months. This study, which also used relative variables, examined the ability of changes in language exposure and vocabulary size to predict TE development during the second and third years of life. It is also the first study to compare a direct measure of TE comprehension with parent report during the second year of life. In sum, it is hoped that these three manuscripts will not only address the goals outlined here in this dissertation, but that they will also make a significant contribution to our understanding of early bilingual vocabulary development and the bilingualism literature at large.

CHAPTER 2

Vocabulary size, translation equivalents, and efficiency in word recognition in very young bilinguals.

Legacy, J., Zesiger, P., Friend, M. & Poulin-Dubois, D. (2016). *Journal of Child Language*, 43(4), 760–783.

Introduction

Because the lexicon is an important domain of language that intersects with phonology, grammar, and literacy development, it has been the focus of much research in the early bilingualism literature (Paradis, 2007). However, with few exceptions, studies contrasting language acquisition in monolinguals and bilinguals have focused primarily on language production. Although there is an extensive literature on word learning abilities in young bilinguals, a limited number of studies have specifically assessed receptive vocabulary development. Moreover, very few of these studies have assessed vocabulary development using experimental procedures. As a result, additional research on receptive language, a primary indicator of early lexical development, is required to fully understand the process of bilingual language development. We report data that show similarities and differences in receptive vocabulary size and efficiency in word recognition between very young bilingual and monolingual children.

To date, the literature suggests that while bilingual infants often have slightly smaller individual vocabularies, their total vocabulary is largely on par with that of monolinguals (De Houwer, Bornstein & Putnick, 2013; Hoff, Core, Place, Rumiche, Señor & Parra, 2012; Junker & Stockman, 2002; Marchman, Fernald, & Hurtado, 2010; Oller & Eilers, 2002; Pearson, Fernández, & Oller, 1993, 1995; Petitto & Kovelman, 2003; Sheng, Lu & Kan, 2011; but see De Houwer et al., 2013 regarding early receptive vocabulary). Although multiple research paradigms have been used to assess early lexical development in bilingual children, most studies have relied on parental reports, such as the MacArthur-Bates Communicative Development Inventories (CDI; Fenson, Dale, Reznick, Thal, Bates, Hartung, Pethick & Reilly, 1993).

Whereas the CDI can be used to assess receptive and productive vocabulary in children 0;8 to 2;6, there are several issues associated with using parental report alone to assess vocabulary development, particularly in bilingual infants. For example, parent-report measures such as the CDI have been found to underestimate monolingual and bilingual infants' vocabulary size (De Houwer, Bornstein, & Leach, 2005; Houston-Price, Mather, & Sakkalou, 2007). In bilinguals, the source of this underestimation is the tendency for a single reporter to complete the parental reports in both languages. As a result, it is important that more than one reporter complete the CDI, particularly if the child is learning his or her second language primarily from one parent or family member, or through daycare. While having the CDI filled out by multiple reporters is the best way to avoid underestimation of an infant's vocabulary, this can be a difficult requirement to meet, particularly if both parents are working outside of the home. Moreover, whereas parents may be able to accurately estimate the number of words their child is able to produce, estimating early comprehension can be more difficult, particularly when a child is exposed to more than one language. Therefore, going forward it is important that studies look at early lexical development using both parental-report measures as well as direct, laboratory-based assessment tools.

To our knowledge, only one study has reported high concurrent validity of the CDI with a laboratory-based measure of vocabulary development in bilinguals. This study, conducted with English-Spanish bilinguals at 2;3, included tasks involving object naming and spontaneous language use, and focused on vocabulary production rather than comprehension (Marchman & Martínez-Sussman, 2002). The present study, however, aimed to provide an accurate estimate of early receptive vocabulary development using both parental report and the Computerized Comprehension Task (CCT) in both monolingual and bilingual infants. As part of this research, we explored the consistency between the CDI and the CCT, and examined how monolingual and

bilingual infants differ with respect to early comprehension and lexical access. We also investigated how exposure to a second language has the potential to impact receptive vocabulary development and lexical access in young bilingual children.

Assessing early vocabulary comprehension using the CCT

The Computerized Comprehension Task (CCT), an assessment tool that builds upon preferential looking and picture book approaches, is a standardized task that requires infants to touch images on a screen in response to auditory prompts from an experimenter (Friend & Keplinger, 2003). It assesses comprehension of 41 words, including nouns, adjectives, and verbs and has been found to be successful in testing infants as young as 1;4. The reliability of the CCT has been found to be high and the convergent and predictive validity with parent reports are strong in monolingual English, French, and Spanish infants (Friend et al. 2012; Friend & Zesiger, 2011). To date, only one study has examined word comprehension in bilinguals using the CCT. Poulin-Dubois, Bialystok, Blaye, Polonia and Yott (2013) found no difference in total vocabulary between monolinguals and French-English bilinguals at 2;0, and reported strong convergent validity of the CCT with the CDI: Words and Sentences, a parental report of productive vocabulary. In the present study, we extend this research to two younger samples at 1;4, comparing the receptive vocabularies of French monolingual and French-English bilingual infants using the CDI: Words and Gestures and the CCT. We also examine the consistency of the CDI: Words and Gestures and the CCT in both the L1 and L2 of French-English bilinguals.

Translation equivalents

An issue that often arises when examining early vocabulary development in young bilinguals is whether they acquire their vocabularies independently from one another (De Houwer et al., 2005). Part of this debate is related to the concept of translation equivalents (TEs),

or words that children acquire in each of their languages for the same concept (e.g. 'dog' and 'chien'). Understanding the acquisition of TEs is important because it not only violates the principle of mutual exclusivity (one word for each object), but it also provides evidence against the hypothesis that bilinguals have a fused or unitary linguistic system. Rather, the presence of TEs supports the notion that bilinguals essentially have two distinct lexical systems, and that they must switch across these two systems depending on the language that is active (Genesee & Nicoladis, 2007; Patterson & Pearson, 2004).

Previous research suggests that young bilingual children begin to acquire TEs by the middle of the second year (Genesee & Nicoladis, 2007; Junker & Stockman, 2002; Quay, 1995; Schelleter, 2002). Whereas children tend to vary in the number of TEs that they accumulate and the rate at which they acquire them, generally speaking the proportion of TEs in a child's overall vocabulary is fairly low before 1;6 (David & Wei, 2008; Pearson et al., 1995; Sheng, Lu & Kan, 2011). As children approach the end of their second year however, this proportion rises steadily, reaching about 30% by the end of the second year (Byers-Heinlein & Werker, 2013; David & Wei, 2008; Lanvers, 1999; Nicoladis & Secco, 2000; Pearson et al., 1995).

Whereas much is known about TEs in relation to children's productive vocabularies, there is a lack of information about the early development of TEs in the receptive vocabularies of bilingual infants. In the only published study of this issue, De Houwer, Bornstein and De Coster (2006) reported translation equivalents in all the French-Dutch infants that they studied at 1;1, ranging from 1% to 61% with a mean proportion of 17%. The current study examines the relation between the proportion of TEs, exposure to a second language, and receptive vocabulary size in bilingual toddlers.

Many factors could influence vocabulary development in young children. For bilingual infants, language exposure, or the amount of time that a child is exposed to a particular language, can have a dramatic effect on lexical development. Increased exposure to a particular language often means that the child has more chances to acquire new words, and this ultimately leads to a larger vocabulary size in that language (David & Wei, 2008; Pearson, Fernández, Lewedeg & Oller, 1997). Conversely, reduced exposure leads to fewer opportunities to acquire new words, and ultimately a smaller vocabulary size. The proportion of TEs is typically influenced by language exposure, with a more balanced exposure resulting in a greater number of TEs (David & Wei, 2008; Pearson et al., 1995; Pearson et al., 1997; Poulin-Dubois et al., 2013).

Lexical access

Vocabulary size, whether assessed with parental report or laboratory tests, provides a static estimate of lexical development. Another critical aspect that could vary across monolinguals and bilinguals is lexical access. Adult bilinguals show deficits in lexical retrieval when performing a verbal fluency task and experience more interference on lexical decision tasks (Gollan, Montoya, Fennema-Notestine, & Morris, 2005; Ransdell & Fischler, 1987; Roselli, Ardila, Araujo, Weekes, Caracciolo, Padilla & Ostrosky-Soli, 2000). Also, bilingual children and adults show poorer accuracy and slower reaction times on picture naming tasks (Kohnert & Bates, 2002), even when naming pictures in their first language (Ivanova & Costa, 2008).

With regard to lasting deficits in lexical retrieval, two main hypotheses have been proposed. One proposition is the weaker links hypothesis, which attributes the poorer access seen in bilinguals to differences in the frequency with which associative networks between words and concepts are used, with monolinguals utilizing these networks with greater frequency than

bilinguals in a particular language (Gollan, Montoya, Cera & Sandoval, 2008). In contrast, the competition hypothesis proposes that more effortful processing is required by bilinguals to access words in each language than by monolinguals because of the need to inhibit interference from a competing language (Dijkstra, 2005; Green, 1998).

Previous studies of online lexical comprehension with monolingual speakers of English and Spanish have shown that over the course of the second year, toddlers become faster in identifying the referents of familiar words presented in continuous speech (Fernald, Pinto, Swingley, Weinbergy & McRoberts, 1998; Hurtado, Marchman & Fernald, 2007). Moreover, early efficiency in lexical processing is associated with a larger vocabulary and with long-term language and cognitive outcomes (Fernald, Perfors & Marchman, 2006; Marchman & Fernald, 2008). Again, only a few studies have examined speed of word processing in young bilinguals. Marchman and colleagues (2010) assessed English-Spanish children's efficiency of spoken language comprehension at 2;6 using the 'Looking-While-Listening' procedure. Although mean reaction time to shift to the correct referent of a series of familiar nouns was as fast for Spanish as for English, speed of lexical access was not correlated across languages. Similarly, fluency in understanding familiar words in one language was linked to the number of words acquired in the same language but unrelated to vocabulary size in the other language. These strong within-language but weak across-language relations remain to be examined at the very early stages of bilingualism.

In a more recent study, French-English bilinguals and monolinguals were administered the CCT at 2;0, with comparisons of both accuracy and reaction time in L1 revealing no differences between the two groups on word retrieval (Poulin-Dubois et al., 2013). A strong concurrent relation was observed between measures of receptive vocabulary size from the CCT

and parental report of productive vocabulary in L1. Interestingly, the more TEs children had in their *expressive* vocabulary, the faster they retrieved the target words in their L1 on the CCT task, as measured by the latency to touch the correct image, independently of total vocabulary. This facilitation has been well documented in adult bilinguals and has been accounted for by the distracter's contribution to the activation level of the target through its activation of the shared conceptual node (Finkbeiner, Gollan, & Caramazza, 2006). The fact that a similar facilitatory effect was found in such young bilinguals is impressive. In the present study, we attempted to replicate and extend these findings by comparing speed of processing of nouns, adjectives, and verbs in French-English bilinguals and French monolinguals at 1;4 using the CCT. By measuring the proportion of TEs in *receptive* vocabulary, efficiency in word recognition, and vocabulary size in both L1 and L2, we were able to test whether the effects observed in older toddlers and adults within and across languages are present early in bilingual language comprehension.

We collected data on 50 bilingual children 1;4 to 1;6 with exposure to French and English from birth (or soon after), and 59 demographically comparable monolingual children with only French input from birth. The aim of the study was to measure monolingual and bilingual infants' word knowledge and speed of lexical access using both direct and indirect measures of receptive vocabulary development. Comprehension was assessed indirectly in English using the CDI: Words and Gestures, and in French using the French adaptations of the original American English CDI. Receptive vocabulary and online processing of words were also assessed directly with the CCT. Based on past research, we hypothesized that bilingual infants would exhibit smaller vocabularies in each of their languages on both the CDI and CCT, but that composite measures of receptive vocabulary would be similar to those observed in the monolingual sample. We also expected that infants would know more words in their L1

compared to their L2, and that exposure to their second language should in part predict infants' vocabulary size in L2, as well as the proportion of TEs in their receptive vocabulary. With respect to online processing of words, we predicted that the bilingual infants would show slower processing, particularly in their second language, on the CCT.

In comparison to most previous studies on vocabulary development in young bilinguals (except De Houwer et al., 2013) our relatively large sample size of bilinguals provided the opportunity to compare vocabulary scores of the monolinguals and bilinguals statistically. In addition, the wide range of exposure to L2 in our sample allowed us to treat relative exposure to L2 as a continuous variable in order to replicate and extend previous research that has shown that proportion of input in one language is positively related to measures in that language and negatively to those in the other language (Hoff et al., 2012).

Method

Participants

Monolingual participants were recruited from Geneva, Switzerland via birth lists provided by the city of Geneva, and tested at the University of Geneva. Bilingual participants were recruited from the Montréal metropolitan area via birth lists provided by a government health agency, and were tested at Concordia University. Infants with visual or hearing problems were not eligible to participate in the study. A total of 138 infants were tested but some were excluded due to fussiness (n = 2), inability to complete testing or failure to return the required language questionnaires (n = 6), or not meeting the language selection criteria (n = 21).

The selection criteria for monolingual participants required that infants' exposure to their L1, French, be 90% or higher. The final monolingual sample consisted of 59 infants between 1;3.19 and 1;5.2 (M =1;4.9) and included 29 females and 30 males, 51% of which were first-

borns. L1 exposure ranged from 90% - 100% with a mean of 98%. Seventy-one percent of the mothers held a University degree.

The selection criteria for bilingual participants required infants to have either French or English as their L1 (assigned based on proportion exposure as reported on the Language Exposure Questionnaire, Bosch & Sebastián-Gallés, 1997; DeAnda, Arias-Trejo, Poulin-Dubois, Zesiger, & Friend, 2015). They also had to have been exposed to their L2 from birth, and not have been exposed to a third language (L3) more than 10% of the time. The final sample consisted of 50 infants between 1;2.27 and 1;7.3 (M = 1;5.9) and included 20 females and 30 males, 70% of which were first-borns. The majority of the mothers (78%) held a University degree. Given the difference in age between groups, all reported comparisons controlled for age.

L2 exposure in the bilingual sample ranged from 19% - 49% (M = 36%, SD = 9%), with infants exposed to their L2 on average 32.76 hours per week. Five participants were also exposed to an L3 on a regular basis with exposure ranging from 1% - 7% (M = 4%, SD = 3%). There were 29 infants with English as their L1 and French as their L2 and 21 infants with French as their L1 and English as their L2. Thirty percent of participants had two bilingual parents each speaking both French and English, 30% of participants had two monolingual parents, one speaking French and the other speaking English, and 40% of participants had either one bilingual and one monolingual parent, or two monolingual parents, both speaking either French or English (in the case of monolingual parents speaking either French or English, L2 exposure occurred through daycare or another caregiver).

Materials

Language Exposure Questionnaire. Estimates of direct language exposure were calculated based on an interview-format administration of the language exposure questionnaire, a

tool that has been used in previous research to distinguish between monolingual and bilingual children (Bosch & Sebastián-Gallés, 1997; DeAnda et al., 2015; Fennell, Byers-Heinlein & Werker, 2007). Parents were asked for information about who speaks to the child on a daily basis, and the amount of time spent with these individuals (family, friends, caregivers, etc.) on a weekly basis. Parents were also asked about the different languages spoken by these individuals. An estimate of how much French and English the child is typically exposed to in a week was then calculated based on this information. The language that each child was exposed to the majority of the time was designated as their L1, and the language that the child heard less often was designated as their L2.

MacArthur-Bates CDI: Words and Gestures (CDI). The CDI contains a vocabulary checklist that consists of 396 words (nouns, verbs and adjectives). It is completed by parents and provides an estimate of a child's receptive vocabulary between 0;8 and 1;6 (Fenson et al., 1993). The French adaptation of the CDI (Kern, 1999) was used for the monolingual group, and the American English (Fenson et al., 1993) and French Canadian (Trudeau, Frank & Poulin-Dubois, 1999) adaptations were used for the bilingual group. Although we requested that the person with the greatest expertise in the target language fill out each CDI, 52% of bilingual participants had the CDI completed by two separate reporters. A comparison of CDI scores based on number of reporters however yielded no significant group differences, and so the data were collapsed across groups for all analyses.

Computerized Comprehension Task (CCT). The CCT is a computer program created by Friend and Keplinger (2003) to directly assess language comprehension in very young children. It is composed of 41 pairs of images containing nouns (23 pairs), verbs (11 pairs), and adjectives (7 pairs), which are matched on size, colour, brightness, difficulty and word class (i.e.

nouns, adjectives or verbs). The two images are presented simultaneously on a computer touch screen with one on the left hand side of the screen and one on the right hand side of the screen in a forced choice format. Infants are asked to touch a target image on the screen. If the target image is touched, the computer emits a reinforcing sound; if it is not touched, no sound is produced. Target images appear equally often on the left and right hand sides of the screen, and there are similar numbers of easy, moderately difficult and difficult words included on each task. All lexical targets were taken from the CDI: Words and Gestures, with word difficulty determined based on normative data from the same form (Dale & Fenson, 1996). Words were categorized as easy if comprehended by 66% of sixteen-month-olds, moderately difficult if comprehended by 33% - 66% of sixteen-month-olds, and difficult if comprehended by less than 33% of sixteen-month-olds. The French adaptation of the CCT (Friend & Zesiger, 2011) contains the same design features with changes in word selection based on French language norms (Kern, 1999; Trudeau et al., 1999). Because these adaptations were originally designed for monolingual samples, only a small proportion of cross-language synonyms were included in the assessment limiting our ability to assess TEs on the CCT.

The version of the CCT software that was used records both accuracy and reaction time automatically, with accuracy calculated as the sum of correct responses for all trials completed. Reaction time was recorded beginning at the moment the target image was presented and ending when the infant touched one of the images presented on the screen. Images remained on screen for a maximum of seven seconds. Trials were coded as missing if the child did not touch the screen. Monolinguals completed the French adaptation of the CCT and bilinguals completed both the French and English adaptations 1 to 2 weeks apart.

Procedure

Upon arrival, participants were first given time to adjust to their surroundings and familiarize themselves with the experimenter. During this time, parents were asked to fill out a consent form and brief demographic questionnaire. The experimenter then carried out a short interview with the parents in order to complete the language exposure questionnaire. Parents of monolingual participants completed the French adaptation of the CDI at home, while parents of bilingual participants were asked to complete in the laboratory the adaptation that corresponded to the language they spoke with the child and have the other CDI completed at home by the person who spoke that language with the child. The number of words indicated on the CDI in the child's primary language was then summed to determine the child's vocabulary size in their L1. This was carried out once more for bilingual participants to determine their vocabulary size in their L2. To determine each child's total vocabulary size, words in L1 and L2 were added together. Cognates, words similar in sound and spelling (i.e. pizza, pizza), were then subtracted from this total. The proportion of TEs was also calculated for each child by determining the number of TE pairs, subtracting cognates and semi-cognates, and dividing this number by the total vocabulary size minus cognates, semi-cognates and non-equivalents. Semi-cognates are pairs of words (one from each language) that sound similar but have slightly different spelling (i.e. bloc, block), while a non-equivalent is a word that exists on one form of the CDI but does not exist on the CDI in the child's other language.

After this initial familiarization period, the experimenter led the infant to a nearby room to begin administration of the CCT. Infants were seated comfortably on a parent's lap within easy reach of the CCT touch screen. Parents were asked to wear darkened glasses and noise-cancelling headphones to prevent parental interference during administration of the CCT. The

experimenter then administered four training trials using easy words so that the child could become familiar with the task. The experimenter was able to administer the training trials twice if needed, in order for the child to fully understand the task prior to beginning test trials. At the beginning of each trial, the screen was blank, and the experimenter asked the child, *Where's the _____? Touch the _____.* or *Who is _____? Touch the one who is _____.* or *Which is _____? Touch the _____ one.* for nouns, verbs and adjectives respectively. The two images then appeared on the screen for a maximum of seven seconds. At the end of the visit, parents received $25 in financial compensation or a voucher for a toy or bookstore for their time and the child received a small toy and certificate of merit. Bilingual participants returned one to two weeks later to complete the CCT in their second language.

Results

Vocabulary size: Parental report vs. CCT

The first set of analyses compared receptive vocabulary size in monolingual and bilingual infants using data from the CDI. As shown in Table 1, bilinguals had a larger receptive vocabulary in their L1 compared to their L2 on the CDI, t (49) = 2.31, p = .03, d = .36. Monolinguals' receptive vocabulary was larger than bilinguals, but only in L2, F (1, 106) = 1.64, p = .028, η^2 = .045. When comparing total receptive vocabulary (total receptive vocabulary – cognates), bilinguals had a significantly larger total vocabulary than monolinguals, F (1, 106) = 14.59, $p < .001$, η^2 = .121. This difference, however, did not hold for conceptual vocabulary (total receptive vocabulary – cognates – semi-cognates – TEs), or for the number of total concepts understood.

The second set of analyses compared receptive vocabulary size in monolingual and bilingual infants using data obtained from the CCT. Both accuracy (number of correct trials out

of trials completed) and reaction time were considered as indicators of performance on the CCT (see Table 2). Bilinguals were equally accurate on the CCT in L1 and L2, with performance on this measure in L1 and L2 positively correlated. The monolinguals however, were significantly more accurate on the CCT than the bilinguals in both of their respective languages, L1: F (1, 106) = 9.39, p = .003, η^2 = .081 and L2: F (1, 106) = 21.17, p < .001, η^2 = .167. However, when total and conceptual vocabulary were considered, the bilinguals appeared to have as many words and concepts as the monolinguals did. In contrast to parent-reported vocabulary on the CDI, direct assessment with the CCT revealed differences between monolinguals and bilinguals in the number of words comprehended in both L1 and L2. When trials with no responses were excluded and the proportion of correct responses (out of correct and incorrect responses) was compared to chance, monolinguals performed above chance, t (58) = 9.89, p < .001 (M = .67, SD = .13). This was also true of the bilinguals in both their L1, t (49) = 4.04, p < .001 (M = .58, SD = .14), and their L2, t (49) = 2.24, p = .03 (M = .55, SD = .16).

Table 2 presents the zero-order correlations between the key variables for bilingual children. In order to correct for multiple comparison tests for this group, the False Discovery Rate procedure was applied, a less conservative correction for Type 1 error than familywise error rate procedures (such as the Bonferroni correction; Benjamini & Hochberg, 1995). As expected, both monolingual and bilingual infants' total score on the CCT was positively correlated with the size of their total receptive vocabulary on the CDI (monolinguals: r (58) = .26, p = .05; bilinguals: r (48) = .39, p = .005). This moderate convergence was also observed when each language was examined separately in the case of the bilinguals, although only statistically significant for L2 (see Table 2). This is consistent with previous research showing that performance on the CCT is convergent with parental report of receptive vocabulary on the CDI

in both groups (Friend & Keplinger, 2008; Poulin-Dubois et al., 2013). As shown in Figure 1, vocabulary size in one language predicted vocabulary size in the other language, regardless of whether vocabulary was measured directly with the CCT or through parental report with the CDI.

Lexical access

Reaction time was calculated by averaging the reaction times of correct CCT trials only. All trials under 300ms were considered to be impulse responses and were excluded from reaction time calculations. There was no difference in reaction time when comparing the bilinguals in their L1 and L2, t (44) = .05, p = .96, d = .01. However, there was no significant difference in reaction time when comparing monolinguals to bilinguals in each of their languages. As shown in Figure 1, speed of processing in one language did not predict speed of processing in the other language. With regard to online word processing and vocabulary, as expected, accuracy on the CCT was negatively correlated with reaction time for monolinguals, r (58) = -.61, p < .001, such that larger receptive vocabularies were associated with faster reaction times and ultimately faster processing of the words in the task. A similar, but much weaker, relation was observed in the case of bilinguals in L2 (r = -.35, p = .014), such that infants who had a larger L2 score were faster at processing words (although in the expected direction, the link between accuracy scores and reaction time in L1 was not significant). However, there was no cross-language transfer between speed of processing and vocabulary (see Figure 1). This is in line with previous work (Fernald et al., 2006; Marchman et al., 2010) showing that larger vocabularies are associated with faster reaction times in a looking task with English monolinguals at 1;6, 1;9 and 2;1, and Spanish-English bilinguals at 2;6. Vocabulary size on the CDI, however, failed to predict online word processing in both groups (see Table 2). The present findings suggest that receptive

vocabulary size similarly affects the propensity of monolingual and bilingual infants to execute a voluntary response in a language task such that a facilitation effect is observed in both groups.

Translation equivalents

The relations between the proportion of TEs, direct and indirect measures of receptive vocabulary, and online word processing were also examined. There were a total of 340 possible TE pairs on the CDI, including 15 cognate pairs (i.e. jeans and jeans), and 21 semi-cognate pairs (i.e. banana and banane). The proportion of TEs was calculated by summing the TE pairs on the CDIs, multiplying by two, and subtracting all cognates and semi-cognates from this total. This number was then divided by the child's total vocabulary – cognates – semi-cognates – non-equivalents (words that do not have a translation). As mentioned before, the proportion of TEs could not be computed using data from the CCT due to limited overlap across the French and English versions. For this reason, we use the mean proportion of TEs in receptive vocabulary on the CDI (M = 53.76%, range: 9.41% - 95.41%) in our subsequent analyses. As expected, the proportion of TEs in comprehension was positively correlated with bilinguals' L2 receptive vocabulary on the CDI (see Table 2). Furthermore, the proportion of TEs in bilinguals' total receptive vocabulary on the CDI was positively correlated with both L2 vocabulary and total vocabulary on the CCT, but not with L1 vocabulary. This suggests that the more words children knew in their second language, the more TEs they had in their lexicon. Similarly, vocabulary size on the CDI in both L1 and L2 predicted the proportion of TEs. However, the number of TEs in comprehension was unrelated to speed of processing (both L1 and L2) and L2 exposure.

Associations between exposure to L2, vocabulary, and lexical access

Lastly, exposure to L2 was examined in relation to both the CDI and CCT. Although L2 language exposure was not significantly correlated with bilingual infants' L1 or L2 receptive

vocabulary on the CDI, the relation between L2 exposure and L2 vocabulary was in the expected direction (p = .053). With regard to the relation between L2 exposure and accuracy on the CCT, the total number of correct trials on the CCT in L1 was negatively correlated with L2 exposure. However, there was no relation between L2 exposure and L2 accuracy on the CCT. These findings suggest that accuracy on the CCT in L1 decreases for bilinguals as their L2 exposure increases, but that the L2 exposure in our sample was not sufficient to facilitate accuracy on the CCT in L2. This may be due in part to variations in the quality of L2 input that children receive, as well as individual differences in word learning capability. However, given that the range of scores at this age in L2 on the CCT was quite small, it is also possible that there simply was not enough variation to produce a positive correlation between these variables.

Discussion

The present study examined lexical development in French-speaking monolingual and French-English bilingual infants using both a parental report and a direct laboratory-based measure of receptive vocabulary development. According to parental report, our sample of young bilinguals had an L1 receptive vocabulary that was on par with that of our monolingual sample. Whereas these young bilinguals appeared to have developed a receptive vocabulary size in L2 that was somewhat smaller than that of the monolinguals, when both L1 and L2 receptive vocabulary were combined, the bilinguals surpassed the monolinguals in their word understanding. When considering the total number of words understood by monolinguals and bilinguals, bilinguals understood 39% more words than the monolinguals. When TEs were taken into account however, and conceptual vocabulary was considered, no difference was observed between the two groups. These findings, based on parental report (CDI), replicate those of recent

studies on receptive and expressive vocabulary (Core & Hoff, 2013; De Houwer et al., 2013; Marchman et al., 2010).

Interestingly, whereas the bilinguals' L1 receptive vocabulary appeared to be on par with that of the monolinguals when measured by parental report, results from the CCT suggest that monolinguals may have an increased level of word comprehension when compared to the bilinguals. Our monolingual sample was significantly more accurate on the CCT when compared to the bilinguals in each of their languages. However, there were no significant group differences in CCT performance as a function of total and conceptual vocabulary. Previous work examining lexical development in infants at 2;0 using the CCT found no difference in accuracy when comparing monolinguals against bilinguals in their L1 (Poulin-Dubois et al., 2012). One interpretation of this pattern of findings is that bilinguals' vocabulary size may catch up to that of the monolinguals by the end of the second year. Alternatively, it is possible that these findings highlight differences in patterns of bilingual development across receptive and expressive domains. Language experience and age-related lexical development in both the receptive and expressive domains may contribute to closing this gap in lexical acquisition.

Regarding the cross-language comparisons in bilinguals, results from the CDI suggest that bilinguals exhibit greater word comprehension in their L1 compared to their L2 at 1;5, but this difference was not revealed by the CCT. A potential reason for this discrepancy between measures–is simply that the CDI assesses a much broader set of items than the CCT such that differences between languages tend to be larger on the CDI. As a result, differences between L1 and L2 (on the order of 1 or 2 words) on the CCT can be easily masked by between-participant variability. A second possibility is that parents are sensitive to their child's exposure to L1 and L2 and use this to guide their comprehension estimates on the CDI, potentially giving children

credit for words or concepts that they do not fully comprehend or that they understand only with the support of contextual information, particularly in L1. In support of this possibility, an analysis comparing infants' performance on the CCT against parental report of the same subset of 41 words found on the CDI yielded significant differences for both L1 and L2, with parents reporting comprehension of 20.62 words in L1 and 16.14 words in L2 on the CDI. This is in contrast to the 11.14 words in L1 and 9.62 words in L2 comprehended on the CCT. Recall that children's performance on the CCT is a direct measure of their decontextualized word knowledge. Thus, although children may exhibit knowledge in the contexts in which parents interact with them, this knowledge may not extend to unfamiliar contexts or exemplars. An ongoing longitudinal study investigating receptive and expressive vocabulary development in the same sample of children at 1;1 and 2;5 will provide a better understanding of developmental changes in word comprehension and production across languages in bilingual children and help to clarify the relation between direct and indirect methods of assessment.

Lexical access

One important contribution of the present study was to assess online processing of words in very young bilinguals. Previous work by Marchman and colleagues (2010) using the Looking-While-Listening paradigm in 2;6 infants learning both Spanish and English from birth, found no difference between L1 and L2 in vocabulary size (as measured by the CDI) or reaction time. Furthermore, whereas they found that vocabulary size and reaction time were significantly correlated within each language, they found no significant correlations between vocabulary size in L1 and L2, or between reaction time in L1 and L2. These findings suggest that efficiency in spoken language recognition and vocabulary knowledge go hand in hand regardless of whether a child is learning one language or two, and that this bidirectional relationship between processing

speed and vocabulary size is confined within a particular language. We replicated, with a much younger sample of bilinguals, the similar vocabulary size in L1 and L2 when it was assessed with a laboratory-based task, the CCT. The replication of a similar speed of word-processing in L1 and L2 in infants at 1;5 using a different, haptic, response modality is also striking. Moreover, as shown in Figure 1, we observed a significant within language relation between vocabulary size in L2 and reaction time on the CCT (although this relation was not significant in L1, the correlations were in the expected direction). Interestingly, our monolingual sample also exhibited this negative relation between reaction time and accuracy on the CCT, which is consistent with previous research showing significant negative correlations between accuracy and reaction time using a preferential looking time paradigm in English monolingual infants at 1;6, 1;9 and 2;1 (Fernald et al., 2006), and Spanish monolinguals at 2;0 (Hurtado et al., 2007). This is particularly important, given that most previous research has utilized latency to look at the target picture as an indicator of word retrieval. Because we utilized a haptic response to derive reaction times in this study, the present findings indicate that this facilitation of reaction time with increased vocabulary size maintains across response modalities in young monolinguals. However, although there were no differences in reaction time for L1 and L2 in bilinguals, this facilitative effect was obtained only for L2 in our sample of French-English bilinguals at 1;5. This difference in findings across studies however may be attributed to many factors, including domain of acquisition (receptive or expressive), age of participants, and response modality (looking or touching). A more similar pattern of results might be observed when the current sample is tested closer to the second birthday.

Although there was considerable variability with respect to L1 and L2 vocabulary size on the CCT, given that the average discrepancy between vocabulary size in L1 and L2 on the CCT

was so small (M = 1.52, SD = 7.03, Range: -21.00 – 18.00), it seems reasonable to assume that no statistical difference in reaction time would exist between languages. Furthermore, this may also explain why reaction time did not significantly differ between monolinguals and bilinguals on the CCT. Whereas the monolinguals on average knew 5.22 more words than the bilinguals on the CCT in L1 and 6.74 more words than the bilinguals in their L2, this discrepancy, although statistically significant, may not be enough to impact speed of lexical access on this task. Bilinguals' total vocabulary knowledge may also contribute to this result to some extent, as overall vocabulary growth is modestly linked with processing speed (Marchman et al., 2010).

Language exposure & TEs

An important aspect of receptive language development in young bilinguals is the amount of lexical input that is received in each of their respective languages. In the present study, exposure to a second language was not significantly correlated with L2 scores on either the CCT or the CDI. This lack of a significant relation between L2 exposure and L2 vocabulary size contrasts with previous research showing that the quantity of exposure to a second language is an important factor in early bilingual language acquisition (David & Wei, 2008; Hoff et al., 2012; Pearson, 2007; Poulin-Dubois et al., 2012). However, it is important to note that although the relation between L2 exposure and L2 vocabulary size on the CDI was not statistically significant, it was in the expected direction. Furthermore, it is possible that the apparent lack of relation between L2 exposure and L2 vocabulary size on the CCT may in part be due to the fact that infants' accuracy on the CCT in L2 was quite low at this age. This more restricted range of scores might have in turn been insufficient to produce a significant correlation between these variables. Alternatively, variation in the quality of L2 input that children are exposed to, as well as individual differences in word learning skills may also be at play here. Importantly however,

we did observe a significant negative correlation between L2 exposure and L1 vocabulary scores on the CCT, suggesting that the larger the quantity of second language exposure, the less accurate these children were on the CCT in their dominant language.

Presumably, more L2 exposure should result in a more balanced L1:L2 ratio, and ultimately a greater number of TEs; however L2 exposure was not correlated with proportion of TEs in receptive vocabulary in the present study. While counterintuitive, this result is actually in line with previous findings suggesting that although balanced language exposure will typically lead to a balanced vocabulary, it does not necessarily result in a higher proportion of TEs (Poulin-Dubois et al., 2013). Whereas a recent study carried out by David and Wei (2008) did show evidence of a significant relationship between language exposure and proportion of TEs, it also included a very small sample of only 13 children. Furthermore, it is possible that in some cases bilinguals may be exposed to their languages in different environments resulting in word learning that is context specific and ultimately leading to a lower proportion of TEs. Finally, this is one of the first studies to use a direct measure of early bilingual development in the receptive domain, and is thus a first step in gaining a better understanding of how children develop in their two languages over time.

Relatedly, no significant association between proportion of TEs in *receptive* vocabulary and reaction time on the CCT was observed. This contrasts previous research in bilingual children at 2;0, which showed that a larger proportion of TEs in *expressive* vocabulary was associated with faster reaction times on the CCT (Poulin-Dubois et al., 2012). In the past, it has been suggested that bilinguals experience interference from the competing language when trying to carry out a task in one of their languages. However, more recent studies examining speed of lexical access in adults indicate a facilitation effect (Finkbeiner et al., 2006). The findings

reported in Poulin-Dubois and colleagues' (2013) study are consistent with these adult data and indicate that the child's competing language may actually act to facilitate lexical access by priming the child at a semantic level.

The lack of replication of this effect when translation equivalents are measured in comprehension suggests that the common semantic representation has to be more robust to facilitate word retrieval. The fact that the link between the proportion of TEs in production and reaction time was in the expected direction (albeit non-significant) supports this interpretation. Importantly, the present sample of infants is significantly younger than the sample investigated in Poulin-Dubois and colleagues' (2013) study, and at the time of testing these children had only begun to develop a productive vocabulary. This means that the number of TEs in their productive vocabulary was quite low. If a facilitation effect requires a more robust semantic representation, then we should see an effect on word retrieval by 2;0 when these children have developed a larger productive vocabulary, and a larger proportion of TEs as a result.

Transfer between languages

Whereas significant positive correlations were observed between the bilinguals' L1 and L2 vocabulary on both the CDI and CCT, no such link was found between efficiency in word processing in L1 and in L2, suggesting that speed of word retrieval in L1 may be largely independent from speed of word retrieval in L2 during the early stages of vocabulary development. Our results replicate the findings of Marchman and colleagues' (2010) study showing significant within-language relations between vocabulary size and speed of processing, but only for a direct measure of word comprehension. The convergence in findings regarding independent speed of processing in L1 and L2 is striking as the previous study examined productive vocabulary development in 2;6 Spanish-English bilinguals using parental report, and

yielded reaction times using eye-tracking methods, whereas the present study used both direct and indirect measures of vocabulary comprehension and a haptic response to assess efficiency in word retrieval. However, our findings diverge from Marchman et al. (2010) regarding cross-language relations in vocabulary. Marchman et al. (2010) reported that vocabulary size in L1 was not related to vocabulary size in L2 for either comprehension or production. Our data showed cross-language transfer for both direct and indirect measures of receptive vocabulary. These conflicting findings may reflect the inclusion of children with very low L2 exposure (as low as 9%) in the Marchman et al. (2010) sample. Nonetheless, at early stages in lexical development, lexical processing skills in the two languages are dissociable as shown by the lack of cross-language convergence in speed of processing but the ability to acquire words seems to converge across languages.

Assessing the consistency of the CDI and CCT

This is the first study to explore the validity of the CCT in a bilingual population, examining the relationship between parental report on the CDI and performance on the CCT in each of their individual languages (see Figure 1). The consistency that was observed between the CCT and CDI vocabulary scores for both monolinguals and bilinguals suggests that the CCT provides a reliable supplement to parental report in assessing vocabulary development in young children. Importantly, it has the potential to act as an objective measure of early language comprehension for monolingual and bilingual infants. However, whereas our bilingual sample was compared to a French monolingual sample in this study, it will be important for future research to examine how these bilingual infants compare to other monolingual samples. Furthermore, although efforts were made to control for age when comparing our monolingual

and bilingual samples, the large age range associated with our bilingual sample is a limitation of the present study.

In sum, the present study highlights both similarities and differences in young monolinguals' and bilinguals' receptive vocabulary development. It is the first study to fully investigate receptive vocabulary development in young bilinguals by examining vocabulary development in each of their individual languages using both parental report and a direct measure of acquisition, the CCT. Our data suggest that early in development bilinguals acquire new words at the same rate or faster than monolinguals, with total vocabulary on average being much larger than that of the monolingual infants. However, when conceptual knowledge is taken into account, there appears to be no difference in rate of language acquisition. This trend in lexical development appears to shift over the course of development however, with bilinguals ultimately possessing smaller vocabularies in each of their respective languages, and a total vocabulary that is on par with that of the monolinguals. This suggests that bilingualism may ultimately lead to a developmental path that is different from that of monolingual individuals. Importantly, the present study emphasizes the importance of using multiple measures to assess receptive language development, and highlights the potential of the CCT as a valid alternative to the CDI in assessing early language comprehension. Furthermore, the samples included in this paper are part of a longitudinal study that will continue to investigate how monolingual and bilingual developmental trajectories change as these children begin school and progress towards the initial stages of literacy.

Table 1. Mean receptive vocabulary scores on the CDI and CCT for monolinguals and bilinguals

	Monolingual (N = 59)			Bilingual (N = 50)				
Variables	Mean	SD	Range	Mean	SD	Range	F-test	Significance
CDI Total Vocabulary	197.05	76.37	43.00 – 387.00	324.70	153.70	63.00 – 693.00	14.59	$p < .001$
CDI Conceptual Vocabulary				236.46	91.89	50.00 – 434.00	2.13	$p = .148$
CDI L1				185.88	90.43	18.00 – 360.00	1.64	$p = .204$
CDI L2				145.68	93.11	10.00 – 406.00	4.94	$p = .028$
CCT Total Vocabulary	16.36	6.93	2.00-32.00	20.48	9.72	4.00 - 41.00	2.27	$p = .135$
CCT Conceptual Vocabulary				19.98	9.37	4.00 - 40.00	1.85	$p = .177$
CCT L1				11.10	6.58	1.00 – 27.00	9.39	$p = .003$
CCT L2				9.66	5.59	2.00 – 26.00	21.17	$p < .001$
Reaction Time L1 (ms)	4165.12	944.31	2282.00-6023.00	3623.28	896.37	2141.00-6027.00	2.83	$p = .096$
Reaction Time L2 (ms)				3676.46	970.43	1284.50-6023.00	2.79	$p = .098$

Table 2. Zero-order correlations between receptive vocabulary variables for bilingual participants (n = 50; RT n = 45)

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. CDI L1 vocabulary	-	.41* p=.002	.84* p<.001	.86* p<.001	.30 p=.036	.21 p=.135	.32 p=.024	.28 p=.049	-.25 p=.078	.53* p<.001	.06 p=.672	-.06 p=.679
2. CDI L2 vocabulary		-	.85* p<.001	.78* p<.001	.23 p=.108	.33 p=.018	.35* p=.013	.37* p=.008	.28 p=.053	.77* p<.001	.07 p=.637	.00 p=.998
3. CDI total vocabulary			-	.97* p<.001	.31 p=.029	.32 p=.023	.39* p=.005	.38* p=.006	.02 p=.899	.77* p<.001	.08 p=.605	-.04 p=.804
4. CDI conceptual vocabulary				-	.31 p=.027	.28 p=.047	.37* p=.008	.35* p=.013	-.02 p=.890	.63* p<.001	-.01 p=.962	.02 p=.916
5. CCT L1 accuracy					-	.34* p=.015	.85* p<.001	.82* p<.001	-.33 p=.019	.24 p=.094	-.23 p=.120	-.20 p=.182
6. CCT L2 accuracy						-	.78* p<.001	.79* p<.001	-.02 p=.889	.37* p=.007	-.03 p=.854	-.36* p=.014
7. CCT total vocabulary							-	.99* p<.001	-.23 p=.113	.38* p=.007	-.16 p=.270	-.31 p=.037
8. CCT conceptual vocabulary								-	-.20 p=.176	.39* p=.005	-.14 p=.344	-.35 p=.018
9. L2 exposure									-	.10 p=.511	.21 p=.162	.09 p=.546
10. TE										-	.22 p=.139	-.11 p=.470
11. Reaction time (RT) L1											-	-.23 p=.134
12. Reaction time (RT) L2												-

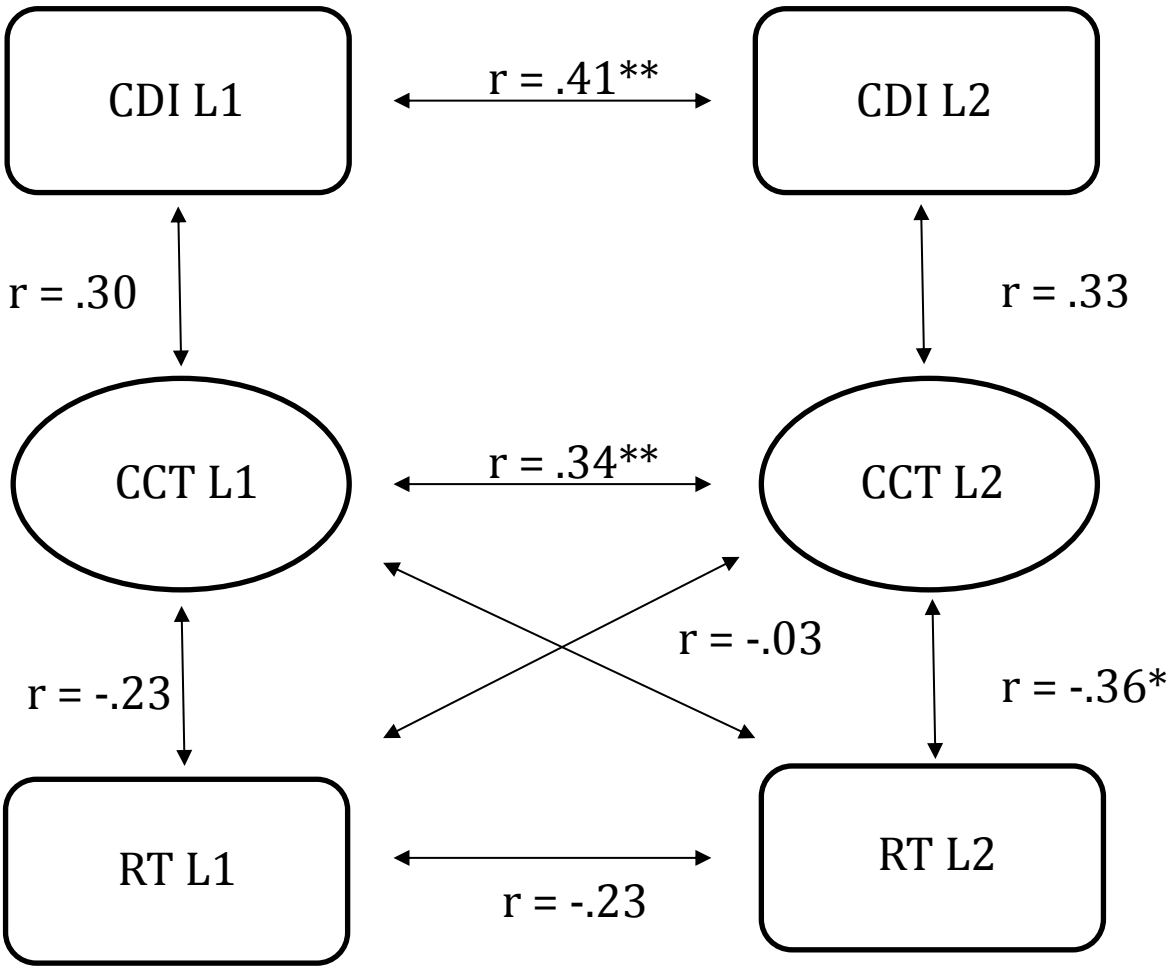

Figure 1. Diagram depicting the relation between performance on the CDI and on the CCT, and between CCT accuracy and reaction time for bilingual infants.

CHAPTER 3

Vocabulary size and speed of word recognition in very young French-English bilinguals: A longitudinal study.

Legacy, J., Zesiger, P., Friend, M. & Poulin-Dubois, D. (2016). *Bilingualism: Language and Cognition*. DOI: https://doi.org/10.1017/S1366728916000833

Introduction

During the second year of life, children undergo a dramatic increase in vocabulary size (Bornstein, Putnick & De Houwer, 2006; Core, Hoff, Rumiche & Señor, 2013; De Houwer, Bornstein & Putnick, 2014; Fernald & Marchman, 2012; Vagh, Pan & Mancilla-Martinez, 2009). Whereas this rapid increase in word knowledge is well established in monolingual children, the typical developmental trajectory of children learning more than one language from birth is not as well documented, especially with regard to receptive vocabulary. The present longitudinal study investigated the stability and continuity of vocabulary growth and speed of lexical access using the Computerized Comprehension Task (CCT; Friend & Keplinger, 2003; Friend, Schmitt & Simpson, 2012; Friend & Zesiger, 2011), a direct, laboratory based measure of receptive vocabulary, in monolingual and bilingual infants between 16 and 22 months of age.

The majority of recent research on early vocabulary development has been cross sectional in nature and has largely focused on vocabulary production in monolingual infants, with relatively fewer studies focusing on vocabulary comprehension, and fewer still on bilingual vocabulary comprehension. Moreover, the bulk of the research on vocabulary comprehension in monolingual and bilingual infants has relied almost exclusively on parental report (De Houwer, Bornstein & DeCoster, 2006; De Houwer, Bornstein & Leach, 2005; De Houwer, Bornstein & Putnick, 2014; Fernald, Perfors & Marchman, 2006; Law & Roy, 2008; Pearson & Fernández, 1994; Stokes & Klee, 2009). Given these limitations in the extant literature, the current study was conducted with the aim of acquiring a better understanding of how bilingual children build their early receptive lexicons. Importantly, the CCT is the first tool of its kind to provide a direct

measure of receptive vocabulary and processing speed during the second year of life. This is much earlier than traditional measures of receptive vocabulary development, such as the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 1997). The main goal of the present study was to use a longitudinal design to directly assess developmental change in word comprehension, in conjunction with parent report of vocabulary production, to gain a better understanding of how bilingual infants' receptive and expressive vocabularies change in relation to monolinguals at a critical period in lexical development.

Of those studies that have looked at the emerging receptive lexicons of bilingual infants, most suggest that receptive vocabulary development is largely on par with that of monolingual infants (De Houwer, Bornstein & Putnick, 2014; Genesee & Nicoladis, 2007). In a landmark study, Pearson, Fernández and Oller (1993) showed that both the total and conceptual (total minus doublets) vocabularies of English–Spanish bilingual children from 8 to 30 months of age were on par with monolingual vocabulary scores over the same period. Whereas significant variability in receptive vocabulary was observed in each of the bilinguals' languages, average vocabulary size in the dominant language was largely equivalent to that of monolingual infants. This pattern of development in the receptive vocabulary of bilingual children has been corroborated by more recent work, suggesting that early bilingual receptive vocabulary develops at a rate that is similar to monolingual acquisition (De Houwer, Bornstein & Putnick, 2014; Poulin-Dubois, Bialystok, Blaye, Polonia & Yott, 2013; Umbel, Pearson, Fernández & Oller, 1992). In contrast, recent work by Thordardottir (2011) suggests that individual vocabulary profiles in older bilingual children depend on children's language exposure history. Moreover, as bilingual children get older, comprehension in each language may

begin to lag behind monolingual norms, making measures of total and total conceptual vocabulary more appropriate when contrasting bilingual and monolingual vocabulary acquisition (Bialystok, Luk, Peets & Yang, 2010; Fernández, Pearson, Umbel, Oller & Molinet-Molina, 1992; Pearson et al., 1993).

Whereas studies on early word comprehension in bilingual infants are scarce, a large literature has focused on early vocabulary production. Several studies suggest that young bilingual children produce fewer words in each language compared to monolingual children (Core et al., 2013; Hoff, Core, Place, Rumiche, Señor & Parra, 2012; Hoff, Rumiche, Burridge, Ribot & Welsh, 2014; Pearson et al., 1993). Moreover, when exposure across languages is unbalanced, they also tend to produce more words in their dominant (L1) versus their non-dominant (L2) language (Hurtado, Grüter, Marchman & Fernald, 2014; Pearson & Fernández, 1994; Pearson et al., 1993). However, when total, and total conceptual, vocabulary are taken into account, bilinguals typically produce as many words as their monolingual peers, although there is some debate as to which of these measures best captures processes of monolingual and bilingual acquisition (Core et al., 2013; Hoff et al., 2012; Junker & Stockman, 2002; Patterson & Pearson, 2012).

Several longitudinal studies on bilingual children 30 months of age and older have reported that, just like monolinguals, bilingual receptive and expressive vocabularies are largely stable, such that early vocabulary size predicts vocabulary size later in childhood (Bornstein, Hahn, Putnick & Suwalsky, 2014; Bornstein et al., 2006; Core et al., 2013; Hammer, Lawrence & Miccio, 2008; Hurtado et al., 2014; Mancilla-Martinez & Vagh, 2013; Uchikoshi, 2006; Vagh et al., 2009). However, further research is required to

determine whether this pattern also holds for receptive vocabulary in very young bilinguals.

Vocabulary growth across languages

Generally speaking, both monolingual and bilingual infants show fairly linear patterns of growth over time with respect to both comprehension and production, although during the second year many children experience a sharp acceleration in growth (De Houwer, Bornstein & Putnick, 2014; Goldfield & Reznick, 1990; Kan & Kohnert, 2012; Pearson & Fernández, 1994; Vagh et al., 2009). While dramatic increases in total receptive and expressive vocabulary have been observed during this period, bilinguals experience this increase in one language at a time, typically in L1 followed by L2 (Pearson & Fernández, 1994).

Interestingly, previous cross-sectional studies examining cross-language relationships in early receptive and expressive vocabulary development in bilinguals have found weak or absent links across languages, suggesting that vocabulary growth in a child's L1 does not always directly predict vocabulary growth in L2 (Kan & Kohnert, 2008; Marchman, Fernald & Hurtado, 2010). However, a recent study conducted by Kan and Kohnert (2012) using a dynamic measure of receptive and expressive vocabulary development (a word learning task) suggests otherwise. Although the results from this study seem to contradict previous research by providing evidence of cross-language relationships in bilingual vocabulary development, Kan and Kohnert's use of a dynamic measure involving the rate of change in novel word learning, rather than static observations of vocabulary size or online speech processing, may have tapped more directly into the processes involved in early vocabulary development. Their study suggests that existing vocabulary size, as well as exposure to each language, has

significant effects on word learning and later vocabulary comprehension and production in bilingual children. Importantly, however, there is currently a lack of longitudinal studies in the literature aimed at gaining a better understanding of the relation between rates of vocabulary growth across languages in bilingual infants. In the present research, we used a longitudinal design and a multi-method approach (parent-reported vocabulary production on the CDI and a touching-while-listening paradigm), to acquire a more comprehensive understanding of the stability at the individual level and continuity at the group level of both receptive and expressive vocabulary development in very young French–English bilingual children.

Speed of online word processing

Numerous studies have now looked at speed of online word processing in both infants and young children, with most of these studies emphasizing the relation between language exposure, early vocabulary development, and processing speed. Recent work using the Looking-While-Listening paradigm (LWL), which involves tracking of infants' eye gaze as they are prompted to attend to a target image on a screen, has provided crucial information about early online processing of words. Two recent studies using the LWL procedure with samples of 18-month-old monolinguals have shown that both existing vocabulary and processing speed work in conjunction with one another to facilitate word learning, with efficiency in word recognition at 18 months of age being positively correlated with accelerated vocabulary growth over the following year (Fernald & Marchman, 2012; Fernald, Marchman & Weisleder, 2013). This finding was paralleled in a longitudinal study carried out by Fernald et al. (2006) with English-speaking monolingual 15-, 18-, 21- and 25-month-olds, which showed increases in word processing speed over time. Moreover, they were able to show stability in speed and

accuracy in spoken word recognition, with performance at 15 months of age predicting the same measures at 25 months of age; children who were faster and more accurate at 25 months of age were also those who showed faster and more accelerated growth in parent-reported expressive vocabulary across the second year. These studies seem to suggest that vocabulary size and online processing abilities work in conjunction with one another to facilitate uptake of input in the environment, ultimately increasing rates of growth over time.

In bilinguals, similar patterns are observed. Marchman and colleagues (2010) reported that although Spanish–English bilinguals at 30 months of age had comparable expressive vocabulary sizes in L1 and L2, they fell below monolingual norms in each of their individual languages. A composite measure of expressive vocabulary however was on par with monolingual norms. Interestingly, no differences were observed between processing speed in L1 and processing speed in L2 on the LWL task. Moreover, whereas vocabulary size in L1 was predictive of processing speed in L1 and vocabulary size in L2 was predictive of processing speed in L2, no cross-language relationships were observed for these variables. Total vocabulary scores, however, were to some extent predictive of processing speed in both Spanish and English, suggesting that overall vocabulary knowledge influences speed of online word processing and vice versa. Similar relations were found between relative receptive and expressive vocabulary size and processing speed in a sample of Spanish–English bilinguals at both 30 and 36 months of age, with evidence suggesting that these relations are stable across the second year (Hurtado et al., 2014).

Although the research by Marchman et al. (2010) and Hurtado et al. (2014) clarifies the relation between vocabulary size and online processing in Spanish–English

bilingual children in the third year of life, our knowledge remains limited regarding how processing efficiency influences stability across languages during the period of accelerated vocabulary growth in the second year (MacLeod, Fabiano-Smith, Boegner-Pagé & Fontolliet, 2013; Hoff et al., 2012; Schwartz, Moin & Leikin, 2012). The present study aimed to extend the findings of Marchman et al. (2010) and Hurtado et al. (2014) by using a direct measure of word comprehension to assess receptive vocabulary growth and processing speed in the second year (Friend & Keplinger, 2003; Hendrickson, Mitsven, Poulin-Dubois, Zesiger & Friend, 2014; Legacy, Zesiger, Friend & Poulin-Dubois, 2016). Our goal was to assess online processing much earlier in development, as well as to determine how speed of online word processing changes over time during the second year of life, a critical period for lexical growth. Assessing infants at 16 months of age, and again six months later, at 22 months of age, made it possible to examine both within- and cross-language relations.

Language exposure

One of the most important factors related to early vocabulary development and speed of word processing is language exposure (Barnes & Garcia, 2012; Bosch & Ramon-Casas, 2014; DeAnda, Arias-Trejo, Poulin-Dubois, Zesiger & Friend, 2016; Hurtado et al., 2014; Poulin-Dubois et al., 2013). Whereas presumably balanced exposure across languages should result in balanced rates of acquisition, most bilingual children are not equally exposed to the languages that they hear (Hoff, 2013). Recent research suggests that generally speaking, strategies such as the one-parent-one-language rule do not provide children with balanced exposure to each language (De Houwer, 2007). The language preference of the child, the relative majority status of the languages, and individual differences in the quality and amount of input each parent typically provides

for the child all contribute to uneven patterns of exposure (De Houwer, 2007; Hammer, Hoff, Uchikoshi, Gillanders, Castro & Sandilos, 2014). These differences in language exposure typically result in children keeping pace with monolinguals in their L1, but over time experiencing slower vocabulary development in their L2 (MacLeod et al., 2013).

Importantly, it has recently been suggested that discrepancies between studies regarding the relations between language exposure, vocabulary size, and processing speed, may in part be due to variations in the use of absolute and relative measures of input, both within and across studies. This discussion has centered on the fact that comparing a relative measure, such as proportion of language exposure, with an absolute measure, such as raw scores on the CDI or PPVT, may distort developmental patterns in the data (Grüter, Hurtado, Marchman & Fernald, 2014; Hurtado et al., 2014). Because relative measures such as proportion of language exposure do not account for variations in the quality of input that children hear in each language, it is often the case that correlations between language exposure and raw scores on vocabulary tasks are weak at best. However, accounting for some of this additional variance (by comparing ratios of language exposure to ratios of vocabulary size across languages) is more accurate and can strengthen correlations between these variables. Therefore the present study used this approach to examine relations between language exposure, vocabulary size, and processing speed.

The present study

The goals of the present study were twofold: 1) to extend previous research by investigating the stability and continuity of early receptive and expressive vocabulary development in a sample of French–English bilingual toddlers using a longitudinal design, and 2) to examine the relation between language exposure, vocabulary size, and

processing speed using a direct measure of receptive vocabulary development and reaction time. By addressing these questions, this study will fill gaps in the extant literature on early bilingual vocabulary development, as well as extend previous findings by utilizing an objective measure of receptive vocabulary development and online word processing in the second year of life.

Method

Participants

Bilingual participants were recruited through birth lists provided by a governmental health agency, and were from a large city in eastern Canada, whereas the monolingual participants were recruited through birth lists provided by the Canton of Geneva, Switzerland. In order to be eligible for the study, infants must have had no visual or hearing impairments. Monolingual participants were required to have 90% exposure to their first language (French). Bilingual participants were required to be French–English bilinguals from birth, and needed to have at least 20% exposure to their second language (Wave 1: M = 37%, SD = 9%, Range = 20 – 49%; Wave 2: M = 35%, SD = 9%, Range = 21 – 50%). Exposure to a third language, if any, was below 10%. Seventy-one percent of mothers held a University degree in the monolingual sample, and 78% in the bilingual sample. Participants from Wave 1 were invited six months later for Wave 2 data collection.

The final sample at Wave 1 consisted of 104 participants (45 bilinguals and 59 monolinguals), with bilinguals ranging from 15.30 to 19.07 months of age (M = 17.31), and monolinguals ranging from 15.63 to 17.07 months of age (M = 16.28). In total, 117 participants were tested. However, 13 of these participants were excluded at Wave 1 due to fussiness (n = 7), incomplete data (n = 4), having a large gap between appointments (n

= 1), and experimental error (*n* = 1). The final sample at Wave 2 consisted of 90 participants (38 bilinguals and 52 monolinguals), with bilinguals ranging from 20.77 to 26.27 months of age (*M* = 23.67), and monolinguals ranging from 21.19 to 22.21 months of age (*M* = 21.98). The same children were re-tested, however 22 participants were excluded at Wave 2 for the following reasons: did not meet the language requirements (*n* = 9), fussiness (*n* = 5), and incomplete data (*n* = 8). In addition, there was a 4% attrition rate (5/117 children) from Wave 1 to Wave 2. Due to significant group differences in age at each wave of data collection, all statistical analyses controlled for this variable. No significant differences in maternal education level were observed.

For cross-wave analyses, only infants who were included in the final samples at both Wave 1 and 2 were included. The final longitudinal sample consisted of 34 bilinguals (20 males, 14 females) and 52 monolinguals (27 males, 25 females). In Wave 1, bilinguals were between 15.13 and 19.07 months of age (*M* = 17.25), and monolinguals were between 15.63 and 17.07 months of age (*M* = 16.28). In Wave 2, bilinguals were between 21.77 and 26.27 months of age (*M* = 23.78) and monolinguals were between 21.19 and 22.21 months of age (*M* = 21.98).

Materials

Language Exposure Assessment Tool (LEAT). This questionnaire yields strong internal consistency and accounts for unique variance in children's vocabulary over and above the variance accounted for by global parent estimates of exposure (DeAnda, Bosch, Poulin-Dubois, Zesiger & Friend, 2016*)*. The experimenter conducted an interview with a parent at each wave of data collection to ask who communicates with the child on a weekly basis (e.g., parents, educator, grandparents, etc.), what language they speak to the child, and for how long. An estimate of the proportion of time that the child

was exposed to each language from birth was then calculated at 16 and 22 months respectively.

CDI: Words and Gestures. The CDI: WG is a parent report vocabulary checklist that measures infants' receptive and expressive vocabulary from 8 to 16 months of age. The European French adaptation (Kern, 1999) was used to measure vocabulary in the monolingual group in Geneva, and the American English (Fenson, Dale, Reznick, Thal, Bates, Hartung, Pethick & Reilly, 1993) and Canadian French (Trudeau, Frank & Poulin-Dubois, 1999) adaptations were used to measure vocabulary in the bilingual group. The English, Canadian French, and European French adaptations contain 396, 408, and 414 words, respectively. This CDI form was selected at the first wave of data collection (as opposed to the CDI: Words and Sentences) so that a direct comparison could be made between the receptive vocabulary component of the CDI: WG and the CCT (please see Legacy et al., 2016 for a discussion of these receptive vocabulary comparisons).

CDI: Words and Sentences. The CDI: WS is a parent report vocabulary checklist that measures toddlers' expressive vocabulary from 16 to 30 months of age, and was used at Time 2 of data collection. The English (Fenson et al., 1993), Canadian French (Trudeau et al., 1999), and European French adaptations (Kern, 1999) contain 680, 624 and 691 words, respectively.

Computerized Comprehension Task. The CCT (Friend & Keplinger, 2003; available at http://childes.psy.cmu.edu/cct/) directly assesses receptive vocabulary in infants. The program is administered on a touch screen, on which two images appear simultaneously, and the infant is asked to touch a target image. The infant has 7 seconds to respond, as the trial times out after that. There is an auditory reinforcement for every correct touch, which consists of an automated voice labeling the noun, verb, or adjective

(e.g., *bubbles*, *jumping*, or *wet*) and a subsequent sound associated with the noun, verb, or adjective (i.e., bubbles popping, children giggling, or water splashing). There are two forms of the CCT (Form A and B) such that the target images on one form serve as the distractor images on the other. For each form, there are four practice trials, administered to make sure that the child understands the task, and 41 test trials. The test trials consist of 41 pairs of images; 23 noun pairs, 11 verb pairs, and 7 adjective pairs, which are balanced for size, colour, brightness, difficulty level, and word category. The target appears equally as often on the left and right sides of the screen, and there are similar numbers of easy, medium, and difficult words. A word was classified as easy if more than 66% of 16-month-olds comprehended the word, moderate if 33 – 66% of 16-month-olds comprehended the word, and difficult if less than 33% of 16-month-olds comprehended the word (Dale & Fenson, 1996). In order to determine the difficulty level of each word for the English CCT, normative data from the CDI: WG was used (Dale & Fenson, 1996). A French adaptation of the CCT was developed in the same way using the French adaptation of the CDI (Friend & Zesiger, 2011). The French adaptation included many of the same items as the English CCT and included a few modifications to reflect cultural differences. Stimuli were presented in the same pseudo-randomized fashion across participants following Hirsh-Pasek and Golinkoff (1996), such that the target did not appear in the same left-right orientation more than twice in a row. Administration of the CCT followed the procedure described by Friend, Schmitt and Simpson (2012). Importantly, the CCT exhibits good test-retest reliability and convergence with parent report (Friend & Keplinger, 2008).

Procedure

At each wave, monolinguals came for one visit in French, and bilinguals came for two visits, one in French and one in English, approximately two weeks apart. Parents were first interviewed using the LEAT to obtain an estimate of each child's language exposure. Following this, parents of monolingual children filled out the European French CDI: WG and parents of bilingual children filled out the Canadian French and English CDIs. The CCT was then administered in an adjoining room, where language and form were counterbalanced across visits. Infants were seated on their parent's lap at a distance where they could easily touch the screen. Parents wore opaque glasses and noise-cancelling headphones to prevent interference.

Prior to beginning the test trials, the experimenter presented the child with four practice trials in order to familiarize them with the touch screen. Once the child showed an understanding of the task, the experimenter presented the child with two images and prompted them to touch a target image by saying: "Where's the _____? Touch _____." for nouns; "Who is _____? Touch _____." for verbs; and "Which one is _____? Touch _____." for adjectives.

Participants returned to the laboratory six months after Wave 1, and followed the same procedure. Thus, the LEAT and CCT were re-administered, and parents filled out the CDI: WS. At the end of each session in Wave 1 and 2, parents received 25$ in compensation, and children received a small gift and a certificate of merit.

Results

One goal of the present study was to assess vocabulary comprehension and production longitudinally in monolingual and bilingual infants at 16 and 22 months of age, in order to obtain a better understanding of how children acquiring more than one

language from birth build their emerging lexicons during a period of rapid vocabulary acquisition. Previous findings (Legacy et al., 2016) suggest that parent report may overestimate vocabulary comprehension in young bilinguals. As such, vocabulary comprehension was assessed in both groups of infants using the CCT, and vocabulary production was assessed using the CDI. Given the significant difference in age between the monolingual and bilingual samples, ANCOVAs were performed for each variable with age entered as a covariate. Table 3 presents the scores on each measure at each wave of data collection for the monolinguals and bilinguals, and Table 4 presents the difference scores across testing occasions on each measure.

Receptive vocabulary

At both 16 and 22 months of age, the bilinguals were able to comprehend more words in their L1 compared to their L2 on the CCT, Wave 1*:* F (1, 43) = 4.30, p = .044, partial η^2 = .091; Wave 2: F (1, 37) = 12.83, p = .001, partial η^2 = .257. They were also significantly less accurate than the monolinguals on this task in both their dominant and non-dominant languages at both waves of data collection (see Table 3 for between-group comparisons). However, although both L1 and L2 accuracy lagged behind that of the monolinguals at each wave, the bilinguals comprehended more words than the monolinguals when total vocabulary (L1 plus L2) was used.

When considering growth across waves (Wave 2 – Wave 1), the results indicate that, as expected, both bilinguals and monolinguals improved their performance on the CCT over this 6-month period, suggesting a steady progression in lexical development (see Table 4). The bilinguals appeared to accumulate approximately as many new words in their L2 (M = 14.44, SD = 6.89) as they did in their L1 (M = 16.59, SD = 7.22), F (1,33) = 2.04, p = .163, η^2 = .058, and no differences in growth were observed when

comparing the monolinguals to bilinguals in each of their languages. Importantly, although accuracy on the CCT at Wave 1 was correlated with accuracy on the CCT at Wave 2 for the bilinguals in L1, r (32) = .45, p = .009, it was not correlated across waves for the bilinguals in L2, r (32) = .27, p = .124. A positive correlation was also observed for the monolinguals, r (50) = .37, p = .006. This suggests that whereas stability across waves exists for the monolingual infants and the bilinguals in their dominant language, there is a lack of stability in vocabulary acquisition for the bilinguals in their non-dominant language. Moreover, the larger bilingual children's vocabularies were on the CCT at 16 months of age, the fewer new words they accumulated across this 6-month period (L1: r (32) = -.74, p < .001; L2: r (32) = -.51, p = .002). This was also the case for the monolingual infants, r (50) = -.63, p < .001. Importantly, however, neither sample of infants reached ceiling on this task, which suggests that this result is not simply due to children with larger vocabularies having fewer words to learn across waves.

Expressive vocabulary

At 16 months of age, both the bilinguals and the monolinguals had only begun to build their productive vocabularies, as measured by the CDI. Interestingly, whereas the bilinguals were able to produce more words in their L1 compared to their L2, F (1,44) = 6.80, p = .012, partial η^2 = .134, they did not significantly differ from the monolinguals with respect to production in either of their individual languages (see Table 3). When L1 and L2 were combined to create a measure of total vocabulary, it appeared that the bilinguals were able to produce significantly more words than the monolinguals. At 22 months of age, this difference between bilingual composite measures of vocabulary and monolingual scores on the CDI disappeared. Moreover, the gap between L1 and L2 was maintained for the bilinguals, F (1,37) = 19.05, p < .001, partial η^2 = .340, and the

monolinguals surpassed the bilinguals with regard to production in L2. Looking across waves, both groups increased their production, with bilinguals acquiring significantly more new words in their L1 compared to their L2, F (1,33) = 16.14, $p < .001$, partial η^2 = .328. Bilinguals also showed similar rates of growth in L1 and L2 relative to the monolinguals (see Table 4), with production scores at Wave 1 correlated with production scores at Wave 2 for both the monolinguals, r (50) = .55, $p < .001$, and bilinguals, L1: r (32) = .69, $p < .001$; L2: r (32) = .50, $p < .001$, suggesting stability in vocabulary size across waves. Further, there was no indication that differences in growth across languages could be attributed to changes in exposure over time: mean exposure to L2 was consistent over time at the group level (*Ms* = 37% and 35% at Waves 1 and 2, respectively). However it is important to note that, although growth in vocabulary over time was expected in both groups, the extent of this growth might be inflated due to the use of different forms of the CDI at 16 and 22 months of age since the CDI: WG administered at 16 months assesses children on fewer items than the CDI: WS administered at 22 months.

Reporter effects

Whereas no significant differences existed between the monolingual and bilingual samples in either L1 or L2 on the CDI at Wave 1 of data collection, by Wave 2 the gap between bilinguals' expressive vocabulary in L1 and L2 had widened such that a significant difference emerged between the monolinguals and the bilinguals in L2. This suggests that whereas bilinguals seem to be able to keep pace with monolinguals when it comes to producing words in their dominant language, their expressive vocabulary in L2 appears to develop more slowly over time. This difference in expressive ability across languages may in part be due to a rapid increase in vocabulary acquisition occurring in

the bilinguals' dominant language. As discussed earlier, expressive vocabulary growth in L2 appears to slow down as new words are rapidly acquired in L1. Alternatively, an imbalance in either the quantity or quality of language exposure could be affecting vocabulary development in the bilinguals' non-dominant language, ultimately leading to a discrepancy in vocabulary growth across languages. Although both of these explanations are plausible, it is also possible that reporter effects on the CDI could have resulted in the observed findings. However, post-hoc analyses revealed that differences in L1/L2 expressive vocabulary measured by parent report on the CDI were mirrored, at the individual level, in differences in L1/L2 receptive vocabulary measured directly on the CCT. That is, when the bilingual sample was divided into two groups based on the number of expert reporters that filled out the CDI, children who exhibited differences in L1 and L2 vocabulary size on the CDI also exhibited such differences on the CCT (children with two expert reporters: Wave 1 CDI: t (22) = 3.11, p = .005, d = .652; Wave 1 CCT: t (22) = 2.09, p = .048, d = .435; Wave 2 CDI: t (30) = 4.00, p < .001, d = .743; Wave 2 CCT: t (30) = 2.96, p = .006, d = .614; children with one expert reporter: no statistically significant differences).

Speed of online word processing

Another important goal of the current study was to investigate the relationship between early vocabulary development and speed of online word processing as measured by latency to touch the target image. In order to address this goal, group differences in reaction time (RT) on the CCT were examined. Five bilingual participants were excluded from the RT analyses at Wave 1 due to technical difficulties resulting in missing RT data. This resulted in a longitudinal RT sample of 31 bilingual participants.

At 16 months of age, bilinguals were as fast to respond to correct trials on the CCT in L2 as they were in L1, F (1,39) = .025, p = .875, partial η^2 = .001. Moreover, these young bilinguals responded as quickly as the monolinguals on this task (see Table 3). This result was also observed at 22 months of age, F (1,37) = 1.76, p = .193, partial η^2 = .045, with no differences between the groups. Although both groups significantly decreased their RTs across waves (see Table 4), there were no significant differences between groups or languages with respect to this reduction in RT, F (1,30) = .164, p = .688, partial η^2 = .005.

Interestingly, at the first wave of data collection, vocabulary size on the CCT was negatively correlated with RT for monolinguals, r (57) = -.66, p < .001, with a trend toward the same result for vocabulary size and RT in L2 for bilinguals, L2: r (38) = -.30, p = .060. The correlation between vocabulary size and RT in L1 for bilinguals was in the expected direction (L1: r (38) = -.25, p = .118) but not significant. Whereas vocabulary size in L1 and L2 were positively correlated, r (43) = .39, p = .008, this relation did not hold for RT. At the second wave of data collection, these within-language correlations remained for the monolinguals, r (50) = -.63, p < .001, and for the bilinguals in L1, r (36) = -.35, p = .031, and L2, r (36) = -.39, p = .016. Vocabulary size in L1 and L2 on the CCT was also correlated at Wave 2, r (36) = .46, p = .004, as was RT in L1 and L2, r (36) = .64, p < .001. Lastly, unlike the stability observed for receptive vocabulary on the CCT and expressive vocabulary on the CDI, RT on the CCT was not correlated across waves for either bilinguals or monolinguals.

Language exposure, vocabulary size and processing speed

In order to investigate the relation between language exposure, relative vocabulary size, and relative processing speed, ratios were calculated for each child by

dividing their score in English by their score in French. Log transformations were then applied to these ratios, and bivariate correlations were run using these relative measures (Hurtado et al., 2014). At 16 months of age, language exposure was positively related to expressive vocabulary size on the CDI, r (43) = .68, $p < .001$, with the correlation being in the expected direction but not significant for receptive vocabulary on the CCT, r (43) = .23, p = .126. Language exposure at 22 months of age was positively correlated with concurrent receptive, r (36) = .34, p = .036, and expressive, r (36) = .70, $p < .001$, vocabulary size, with language exposure correlated across waves, r (32) = .64, $p < .001$. Interestingly, neither language exposure nor vocabulary size was correlated with processing speed at either wave of data collection.

Developmental trends in language exposure, vocabulary size and processing speed

Importantly, language exposure at Wave 1 was a significant predictor of both receptive vocabulary on the CCT (see Table 3; r^2 = .22, F (1, 29) = 8.14, p = .008; β = .47, p = .008), and expressive vocabulary on the CDI (r^2 = .24, F (1, 29) = 8.92, p = .006; β = .49, p = .006) at 22 months of age, accounting for 22% and 24% of the variance, respectively, in the bilingual sample. Similarly, vocabulary size at Wave 1 significantly predicted vocabulary size at Wave 2 in the monolingual sample, as expected (CCT: r^2 = .14, F (1, 50) = 8.15, p = .006; β = .44, p = .018; CDI: r^2 = .30, F (1, 50) = 21.08, $p < .001$; β = .55, $p < .001$). Importantly, processing speed at 16 months was a significant predictor of vocabulary size on the CCT, but not on the CDI, at 22 months of age for the bilinguals (see Table 5; r^2 = .11, F (1, 28) = 4.72, p = .038; β = .34, p = .008). Interestingly, processing speed at 16 months did not predict receptive or expressive vocabulary at 22 months of age in the monolingual sample.

Discussion

The goals of the present study were twofold: 1) to investigate the stability and continuity of early receptive and expressive vocabulary development in a sample of French–English bilingual toddlers using a longitudinal design, and 2) to examine the relation between language exposure, vocabulary size, and processing speed using a direct, laboratory-based measure of receptive vocabulary and RT. Our findings provide new evidence about lexical development during the second year in French–English bilingual children.

Vocabulary growth

At both 16 and 22 months of age, bilingual toddlers comprehended more words in their L1, as measured directly with the CCT, than they did in their L2. However, over the 6-month testing interval, bilingual infants accumulated as many new words in their L2 as they did in their L1 suggesting a balanced rate of acquisition. The first finding, that vocabulary size was larger in L1 than in L2 at each wave, parallels our findings on parent reported expressive vocabulary on the CDI, which showed that the gap between bilingual infants' dominant and non-dominant languages emerges early and is maintained over time. However, the fact that children acquired approximately as many new words in L2 as they did in L1 across waves, despite uneven levels of exposure to each language, suggests accelerated rates of vocabulary growth in their L2 during this period of development. Previous findings suggest that as toddlers' vocabularies become more balanced, they are more likely to integrate translation equivalents (TEs; words in each language for the same concept, such as *dog* in English and *chien* in French) into their vocabularies (Legacy, Reider, Crivello, Kuzyk, Friend, Zesiger & Poulin-Dubois, 2016). This process may help to account for a higher rate of acquisition in L2 relative to L1.

That relative language exposure predicted relative vocabulary growth across waves suggests that relative language exposure plays a strong role in the construction of bilingual children's early lexicons.

Stability of vocabulary size and processing speed

Results from the CCT and CDI suggest both acceleration and stability in receptive and expressive vocabulary size across waves for the monolinguals and bilinguals. However, whereas the CDI suggests stability in expressive vocabulary development for the bilinguals in both of their languages, the CCT evinced stability only in the dominant language, such that receptive vocabulary scores in L1 were positively correlated across waves. One possibility for this discrepancy is a true lack of stability in bilingual infants' L2 receptive vocabulary that is not reflected in parent reported expressive vocabulary. Our behavioural findings are consistent with Bornstein and colleagues' (2014) recent study on the stability of language development in monolingual children. They report that receptive and expressive core language skills are less stable from 20 months to 4 years of age than they are from 4 years of age to 10 years of age. Bilinguals' L2 CCT accuracy scores might be particularly susceptible to this lower stability, given the increased variability in input that is often experienced by bilingual infants. Moreover, although there is data to suggest that performance on the CCT is stable from 16 to 20 months of age for monolingual infants (Friend & Keplinger, 2008), this is the first study to examine the stability of the CCT in a bilingual sample of infants. Thus, direct assessment of receptive vocabulary in the second year suggests differential stability across dominant and non-dominant languages.

Although L1 receptive vocabulary size on the CCT and L1 and L2 expressive vocabulary size on the CDI were fairly stable during the second year, RT on the CCT was

not correlated across waves for neither monolingual nor bilingual toddlers. Importantly, previous research with monolingual infants has shown that RTs are variable early in development and become more stable over time. For example, Fernald et al. (2006) investigated the stability of RTs using the LWL procedure in a sample of English-speaking infants at 15, 18, 21, and 25 months of age. They found that although RTs were correlated across 18 and 21 months, and marginally correlated across 21 and 25 months, RTs were not correlated across 15 and 18 months of age. That RT was not correlated across waves for both the monolingual and bilingual samples in the present study is consistent with previous research documenting limited stability in processing speed early in development.

Cross-language relations in bilinguals' vocabulary size and word processing speed

Importantly, cross-language relations were observed for receptive vocabulary on the CCT and expressive vocabulary on the CDI at both waves of data collection. This is in contrast to previous research finding an absence of cross-language relationships in vocabulary size in 30-month-old Spanish–English bilinguals (Marchman et al., 2010). Expressive vocabulary in L1 at Wave 1 significantly predicted expressive vocabulary in L2 at Wave 2, with a trend observed for a relation between L2 vocabulary at Wave 1 and L1 vocabulary at Wave 2. The presence of cross-language relationships across measures at each wave suggests some transfer between languages. This transfer appears to be bidirectional, with vocabulary development in L1 impacting vocabulary development in L2 and vocabulary development in L2 impacting vocabulary development in L1, both within and across waves. Within-language relations between vocabulary scores on the CCT and RT emerged at 16 months of age for monolinguals and for bilinguals in L2. These within-language relations were maintained at 22 months in both groups and

extended to L1 in bilinguals. Also by 22 months of age, RTs in L1 and L2 were positively correlated reflecting the impact of general working memory and processing skills required for online language processing.

Consistent with Hurtado et al. (2014) and Marchman et al. (2010), the present findings show that monolingual and bilingual children with larger vocabularies are faster at online processing of words, and that language exposure predicts vocabulary size. However, although these studies found significant relations between language exposure and RT using both raw scores and relative ratios, these relations were not replicated in the present study. One possible reason for these discrepancies is the age of the children, with both prior studies investigating these relations in 30-month-old children. Importantly, these older samples exhibited much larger, and possibly more decontextualized vocabularies, than children in the present study. Recall that one goal of this present research was to extend previous findings to younger children in a period of rapid acceleration of vocabulary growth. Thus, it is possible that the relation between exposure and RT emerges after this period. This may follow from the finding that RT is unstable early in development. Alternatively, differences in procedure may have contributed to the discrepancy between our findings and previous research. Both Hurtado et al. (2014) and Marchman et al. (2010) used the LWL procedure to measure receptive vocabulary, which differs in many respects from the CCT. One key difference across the two measures is the degree to which target words vary according to difficulty. Whereas the LWL only includes words that are "highly familiar" to children based on lexical norms for the target age range and parent report of the child's word knowledge, the CCT incorporates easy, medium, and difficult words based on lexical norms, and children may not be familiar with all of the words included on the CCT. To test whether this difference contributed to

the discrepancy in findings, we analyzed easy word trials on the CCT separately (words that are normatively familiar). However, the same pattern of results was observed with no strengthening of the relation between exposure and RT. Another procedural difference is that LWL and the CCT differ in the degree of volition required to execute a response. Whereas LWL measures an automatic visual response, the CCT requires much more effort on the part of the child in order to produce a response. This volitional component might in turn lead to variations in RT from those observed using a more automated response. It is possible that differences in response modality contributed to the absence of a relation between exposure and RT in the present study. More interesting, however, is the possibility that the relation between exposure and RT emerges once vocabulary growth and processing speed stabilize in the third year.

Language exposure, vocabulary size and processing speed

Our findings replicate Hurtado et al. (2014) showing that language exposure predicts relative vocabulary size over the course of development. However, whereas Hurtado et al. (2014) found this relation in a sample of 30-month-old Spanish–English bilinguals using the PPVT/TVIP and CDI, we have replicated and extended this finding to a younger sample of 16-month-old French–English bilinguals, using the CCT and CDI as measures of receptive and expressive vocabulary respectively. In addition, Hurtado et al. (2014) found that relative processing speed, as measured using the LWL procedure, was a significant predictor of receptive and expressive vocabulary size in children from 30 to 36 months of age. This result was observed for bilinguals in the present study using the CCT as a measure of receptive vocabulary size and RT. Importantly, however, language exposure was not related to RT within or across waves, which diverges from Hurtado et al.'s (2014) findings. In addition, the relation between vocabulary size and

processing speed was observed for receptive vocabulary but did not extend to expressive vocabulary on the CDI at 22 months. The present study examined these relations in a much younger sample, with key differences present across RT modalities. The instability of RT early in development (e.g., Fernald et al., 2006) may also have contributed to the lack of relation between processing speed, language exposure, and expressive vocabulary. Nevertheless, the fact that processing speed was observed to predict receptive vocabulary outcomes across a 6-month period for a sample of very young bilinguals emphasizes the bidirectional nature of the relation between online word processing and vocabulary growth.

Interestingly, in the monolingual sample, RT at 16 months did not predict vocabulary size at 22 months, above and beyond initial vocabulary size. Previous studies reporting links between vocabulary size and processing speed in monolinguals have done so at a single point in time rather than longitudinally, or have looked at the link between processing speed and vocabulary retrospectively, finding that children with faster processing speeds at 24 months also had larger vocabularies and acquired more words across the second year (Fernald et al., 2006; Fernald et al., 2013). Our prospective, longitudinal findings suggest that speed of processing is a stronger predictor of language outcomes in bilinguals whereas vocabulary size is a stronger predictor in monolinguals. This may reflect differential processing demands in early bilingual, as contrasted with monolingual, acquisition.

Conclusion

In sum, our findings suggest that bilingual toddlers develop their receptive and expressive vocabularies at approximately the same rate as monolingual toddlers. Whereas both receptive and expressive vocabulary development may begin slowly in bilinguals

with learning divided across languages, over time toddlers acquire approximately as many new words as their monolingual peers in their dominant language. In L1 vocabulary growth, bilingual toddlers keep pace with monolingual peers whereas L2 vocabulary growth is slower with regard to both comprehension and production. However, when total vocabulary is considered, bilinguals comprehend and produce as many, if not more, words than their monolingual peers.

No major differences in processing efficiency were observed across groups or languages at either wave of data collection and both groups significantly decreased their RTs across a six-month period. Nevertheless, interesting relations between vocabulary size and processing efficiency emerged. Children with larger vocabularies were faster at processing words and processing efficiency was predictive of receptive vocabulary acquisition across languages at 22 months of age. Finally, significant cross-language relations were observed for receptive and expressive vocabulary size at 16 and 22 months.

In conclusion, this study is the first to investigate vocabulary growth in a sample of French–English bilingual toddlers using a longitudinal design in conjunction with a direct measure of vocabulary development. By examining both expressive and receptive vocabulary growth from 16 to 22 months of age, we have been able to show that bilingual toddlers largely keep pace with their monolingual peers when their dominant language or total vocabulary is considered. Moreover, learning more than one language from birth does not appear to hinder the online processing of words, and may be facilitative of total vocabulary acquisition in young bilinguals. Our findings suggest a complex interplay between language exposure, processing efficiency, and word learning across the first two years of life. Receptive and expressive vocabulary growth across languages provided

evidence of both acceleration and stability across waves in both monolingual and bilingual toddlers. However, further research is required in order to fully understand the long-term developmental trajectory bilingual infants take in acquiring each of their languages.

Table 3. *Monolingual and bilingual comprehension and production scores within each wave.*

	Monolinguals (n = 59)			Bilinguals (n = 45)					
Wave 1	Mean	SD	Range	Mean	SD	Range	F-test	Significance	η^2
CCT total vocabulary (R)	16.36	6.93	2.00-32.00	21.56	9.51	4.00-41.00	4.87	$p = .030$	.093
CCT L1 (R)				11.69	6.55	1.00-27.00	4.67	$p = .033$	.109
CCT L2(R)				10.16	5.62	2.00-26.00	15.33	$p < .001$	.193
CDI total vocabulary (E)	24.02	26.22	0-115.00	85.76	75.44	4.00-355.00	14.33	$p < .001$	.254
CDI L1 (E)				49.98	39.13	4.00-138.00	3.48	$p = .065$	.239
CDI L2 (E)				37.22	42.11	0-238.00	1.73	$p = .192$	.037
Reaction Time L1	4165.12	944.31	2282.00-6023.00	3656.00	924.50	2141.00-6027.00	2.14	$p = .147$	.072
Reaction Time L2				3619.00	949.90	1285.00-5445.00	2.87	$p = .093$	.078
Wave 2	**Monolinguals (n = 52)**			**Bilinguals (n = 38)**					
CCT total vocabulary (R)	29.31	6.12	12.00-40.00	49.97	11.07	17.00-66.00	29.14	$p < .001$	.622
CCT L1 (R)				27.76	6.23	12.00-37.00	6.78	$p = .011$	.076
CCT L2 (R)				23.66	7.19	2.00-35.00	13.83	$p < .001$	.176
CDI total vocabulary (E)	208.14	137.21	28.00-523.00	363.00	236.31	67.00-1027.00	.727	$p = .332$	.186
CDI L1 (E)				225.90	153.43	57.00-643.00	1.60	$p = .210$	.052
CDI L2 (E)				137.11	110.65	3.00-446.00	6.27	$p = .014$	.085
Reaction Time L1	3406.19	899.57	1901.82-5163.54	3155.87	707.20	1856.50-5239.74	.103	$p = .749$	.050
Reaction Time L2				3031.80	642.94	2026.58-5087.75	.209	$p = .649$	.067

E = expressive
R = receptive

Table 4. *Monolingual and bilingual cross-waves difference scores.*

	Monolinguals (n = 52)			**Bilinguals (CCT & CDI n = 34; RT n = 31)**					
	Mean	SD	Range	Mean	SD	Range	F-test	Significance	η^2
CCT total vocabulary (R)	12.56	7.29	-3.00-28.00	29.82	10.77	6.00-54.00	35.65	p = .000	.489
CCT L1 (R)				16.59	7.22	-5.00-30.00	1.24	p = .268	.084
CCT L2 (R)				14.44	6.89	-4.00-30.00	.806	p = .372	.017
CDI total vocabulary (E)	184.19	125.68	19.00-514.00	287.40	189.10	55.00-825.00	5.07	p = .027	.099
CDI L1 (E)				189.20	129.00	19.00-532.00	.004	p = .953	.001
CDI L2 (E)				103.40	97.62	-74.00-344.00	3.81	p = .054	.111
Reaction Time L1	720.89	1278.94	-3212.50-1996.88	-686.00	952.50	-3087.50-753.25	.053	p = .819	.001
Reaction Time L2				-583.00	1071.00	-2688.86-1844.66	.010	p = .920	.010

E = expressive
R = receptive

Table 5. *Multiple regression models (standardized Betas) with English:French ratios of language exposure and processing speed at 16-months as predictors of English:French ratios of receptive (CCT) and expressive (CDI) vocabulary size at 22-months (n = 31).*

	22 months			
	Relative receptive vocabulary		Relative expressive vocabulary	
16-month predictor	Model 1	Model 2	Model 1	Model 2
Relative language exposure	.47**	.41*	.49**	.50**
Relative processing speed (RT)	---	.34*	---	-.07
Total R^2	.22	.33	.24	.24

*p < .05; **p < .01

CHAPTER 4

Dog or chien? Translation equivalents in the receptive and expressive vocabularies of young French-English bilinguals.

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Introduction

Decades of research suggest that bilingual infants reach linguistic milestones, such as babbling and producing first words, at the same rate as monolingual infants, despite the fact that the input that bilingual infants hear is much more complex (Oller, Eilers, Urbano & Cobo-Lewis, 1997; Nicoladis & Genesee, 1997; Pearson, Fernández, Lewedeg & Oller, 1997). Bilingual infants are often exposed to two languages from birth, and they must use the specific properties of this dual input to differentiate one language from the other. Despite these unique challenges, bilingual infants form lexical representations for words in each of their languages early on as they quickly begin to incorporate translation equivalents (TEs) into their vocabularies. TEs, or doublets, are defined as lexical representations that a speaker has in each language for the same concept (i.e. *dog* in English and *chien* in French). Importantly, by the end of the second year, bilingual children's vocabularies are composed of an average of approximately 30% TEs (Bosch & Ramon-Casas, 2014; David & Wei, 2008; Pearson, Fernández & Oller, 1995; Poulin-Dubois, Bialystok, Blaye, Polonia & Yott, 2013), although there is typically a great deal of variability between children. This feat is quite impressive as it suggests that bilingual children are able to understand early on in development that two words can mean the same thing. However, although the acquisition of TEs during infancy is an important part of bilingual vocabulary development, there are still many gaps in the literature on this topic, as most research has centered on case studies, or studies conducted with very small sample sizes. More importantly, most studies on TE acquisition exclusively utilize parent report measures of vocabulary, and very few studies have investigated the development of TEs over time, using longitudinal designs. As a result, our knowledge of the rate of TE development during infancy is quite limited. In

order to address these gaps in the literature, two experiments were conducted. The aim of the first experiment was to examine changes in the proportion of TEs on the MacArthur Bates Communicative Development Inventory (CDI) across three developmental time points. By documenting TE acquisition in a sample of 34 French-English bilingual children at 1;4, 1;10, and 2;6, our goal was to gain a better understanding of how young bilinguals acquire TEs during a period of accelerated vocabulary growth. A secondary goal of this experiment was to acquire a better understanding of how changes in bilingual input and relative vocabulary size shape TE development, by examining the relation between changes in language exposure and relative vocabulary size, and the proportion of TEs. The aim of the second experiment presented in this paper was to investigate the utility of a direct measure of TE comprehension, and to compare the proportion of TEs derived from this measure with parent report of the same subset of words. Within the vocabulary development literature, there has been some concern that parents of bilingual children might confound their child's languages when reporting their receptive word knowledge on vocabulary checklists (Pearson et al., 1995) such as the CDI (Fenson et al., 1993; Trudeau, Frank & Poulin-Dubois, 1999). The goal of this second experiment was to determine whether parent report of TEs mirrors a direct, laboratory-based measure of children's TE development.

Language exposure

The amount of time that a child is exposed to each of his or her languages appears to be significantly related to vocabulary development in each language, with discrepancies in language exposure often leading to unbalanced vocabulary development (Bedore, Peña, Summers, Boerger, Resendiz, et al. 2012; Bosch & Ramon-Casas 2014; Eilers, Pearson & Cobo-Lewis, 2006; David & Wei, 2008; De Anda, Arias-Trejo, Poulin-

Dubois, Zesiger & Friend, 2016; De Houwer, 2007; De Houwer, Bornstein & De Coster, 2006; Grüter, Hurtado, Marchman & Fernald, 2014; Hoff, 2013; Hurtado, Grüter, Marchman & Fernald, 2014; Pearson et al., 1997; Place & Hoff, 2011; Poulin-Dubois, Bialystok, Blaye, Polonia & Yott, 2013; Thordardottir, 2011). Several studies for example now show that young bilinguals tend to produce fewer words in each of their individual languages compared to monolingual infants (Core, Hoff, Rumiche, & Señor, 2013; Oller, Pearson & Cobo-Lewis, 2007; Hoff, Core, Place, Rumiche, Señor, & Parra, 2012; Hoff, Rumiche, Burridge, Ribot & Welsh, 2014; Oller, Pearson & Cobo-Lewis, 2007; Pearson, Fernández & Oller, 1993). Furthermore, when exposure is unbalanced, children also have a tendency to produce more words in their dominant (L1) compared to their non-dominant (L2) language (Hurtado et al., 2014; Pearson & Fernández, 1994; Pearson et al., 1993). Interestingly, however, when total (the number of words a child knows) or total conceptual (the number of concepts a child knows) vocabulary are taken into account, bilinguals are typically considered to produce as many words as their monolingual peers (Core et al., 2013; Hoff et al., 2012; Junker & Stockman, 2002; Pearson et al., 1993).

Given that it is well established that language exposure has a significant impact on early vocabulary development, it is reasonable to think that the relative distribution of exposure in each language might also have an impact on the proportion of TEs that a child acquires. However, whereas balanced exposure should theoretically result in balanced rates of TE acquisition, most children are not equally exposed to the languages that they hear (Hoff, 2013). Recent research has shown that although many parents make an effort to provide balanced levels of exposure for their children, generally speaking, strategies such as the one-parent-one-language rule are not effective in achieving this

goal (De Houwer, 2007). Other factors, such as the language preference of the child, the majority status of the child's languages, the contexts in which they learn their languages, and individual differences in the quantity and quality of input speakers provide for the child all contribute to uneven exposure patterns, and very often, uneven patterns of vocabulary growth (De Houwer, 2007; MacLeod, Fabiano-Smith, Boegner-Pagé & Fontolliet, 2013; Place & Hoff, 2011).

Interestingly, although most bilingual children have at least some TEs in their early receptive and expressive vocabularies (Bosch & Ramon-Casas 2014; Byers-Heinlein & Werker, 2013; De Houwer et al., 2006; Deuchar & Quay, 2001; Genesee & Nicoladis, 2007; Holowka et al., 2002; Junker & Stockman, 2002; Nicoladis & Secco, 2000; Pearson et al., 1993; Pearson et al., 1995; Quay, 1995; Schelletter, 2002), there continues to be some debate in the literature regarding the extent to which quantity of language exposure plays a role in facilitating TE acquisition. Whereas there is evidence to suggest that children who are raised in environments that are more conducive to balanced language acquisition tend to acquire a greater proportion of TEs early on in development (David & Wei, 2008; Montanari, 2010; Pearson et al., 1995; Poulin-Dubois et al., 2013), there are also studies showing that quantity of L2 exposure is a poor predictor of how many TEs a child has in their vocabulary (Byers-Heinlein & Werker, 2013; Lanvers, 1999). Of note is the fact that although there is a great deal of individual variability in the proportion of TEs that a child acquires, we know that TE acquisition generally increases over time in relation to children's vocabulary production (Montanari, 2010). However, although several studies have now examined the process of TE acquisition in young bilinguals, the majority of these studies have been cross-sectional in nature, and few have examined the role that changes in language exposure and

vocabulary ratios play in facilitating the acquisition of TEs longitudinally in the course of early vocabulary development. A main goal of the present study was to examine how changes in relative language exposure and vocabulary size impact TE acquisition in very young bilinguals using a longitudinal design.

Measuring TE acquisition during infancy

To date, the majority of research on TE acquisition in young bilinguals has been conducted using case studies and parent report measures, such as the CDI (David & Wei, 2008; De Houwer et al., 2006; Junker & Stockman, 2002; Legacy, Zesiger, Friend & Poulin-Dubois, 2016). Although the CDI is well established as a valid and reliable measure of vocabulary development in both monolingual and bilingual infants, and is praised for its quick and easy to use format, there has been some concern that parents of bilingual infants might confound their child's languages when reporting their word knowledge on vocabulary checklists (Pearson et al., 1995). Importantly, although the CDI should ideally be filled out by two expert reporters, in the case of bilingual infants, this is not always possible, and most often it is the primary caregiver who fills out both forms of the CDI. Interestingly, De Houwer, Bornstein, and Leach (2005) showed that single reporter CDI reports often underestimate monolingual children's *receptive* vocabulary knowledge. This suggests that inaccurate reporting of vocabulary knowledge by single reporters might also affect bilingual vocabulary estimates, as this task is much more complex for parents of bilingual children. Whereas trying to differentiate the words that a bilingual child *says* in each of their languages can be difficult for parents (Lust et al., 2014), trying to differentiate the words that a child *comprehends* in each language can be even more challenging. As a result, Experiment 2 was conducted to address this issue. By assessing the proportion of TEs that infants' comprehended using a direct, touch-screen

measure of vocabulary comprehension, and comparing these results to parent report of the same subsets of words on the CDI, we were able to determine how accurately parents were able to report on their child's early comprehension of TEs.

The present study

In order to address gaps in the literature surrounding the acquisition of TEs in early bilingual vocabulary development, two studies were conducted. Experiment 1 had two main goals: 1) to gain a better understanding of how French-English bilinguals acquire TEs over time, by examining changes in the proportion of TEs on the CDI across three developmental time points, and 2) to determine the roles that linguistic input and vocabulary growth play in shaping TE acquisition. In order to accomplish these goals, TEs in infants' expressive vocabularies were measured at 1;4, 1;10, and 2;6 using the MacArthur Bates CDI, and changes in language exposure and relative vocabulary size were examined as potential predictors of change in the proportion of TEs across waves. We hypothesized that more balanced ratios of exposure and productive vocabulary size would be associated with larger proportions of TEs at each wave. The purpose of Experiment 2 on the other hand, was to compare a direct, touch-screen measure of infants' TE comprehension with parent report of the same subset of words. We conducted this experiment to test the hypothesis that parents may be under or over reporting their children's comprehension of TEs.

In accomplishing these goals, we aimed to acquire a better understanding not only of what TE acquisition looks like during early bilingual vocabulary development, but also how changes in input and relative vocabulary size shape this development, and how we can best measure the acquisition of TEs in bilingual infants' receptive vocabularies. By using a longitudinal design, as well as a direct measure of early TE comprehension, we

aimed to provide an original contribution to the literature on bilingual vocabulary development.

Experiment 1: Method

Participants

Participants were recruited through birth lists provided by a governmental health agency in Montréal, Canada. In order to be eligible for each study, bilingual participants were required to be French-English bilinguals from birth, and needed to have at least 20% exposure to their second language. Exposure to a third language, if any, was below 10%.

Participants from Experiment 1 attended three waves of data collection, beginning at 1;4. However, due to the longitudinal nature of the study, only children who contributed data at all three waves were included in the final sample. At Wave 1 of data collection, 57 infants participated in the study. However, four children whose parents failed to return the vocabulary checklists were excluded. Participants who completed Wave 1 of data collection were then asked to return six months later for Wave 2. At this wave, a total of 13 additional children were excluded due to missing data (n = 8) or no longer meeting the language requirements for the study (n = 5). Wave 3 of data collection occurred seven months after participants returned for Wave 2. At this wave, six additional participants were excluded due to missing data (n = 4) or no longer meeting language requirements (n = 2).

The final cross-wave sample consisted of 34 bilinguals (19 males and 15 females). At Wave 1, children ranged in age from 1;3.0 to 1;6.17 (M = 1;5.8) and were exposed to their non-dominant language an average of 36% of the time (M = 36%, SD = 8%, *Range* = 22% – 48%). At Wave 2, children ranged in age from 1;10.29 to 2;1.10 (M

= 1;11.20) with a mean level of L2 exposure of 36% (*M* = 36%, *SD* = 10%, *Range* = 21% – 50%). Finally, at Wave 3 children ranged in age from 2;3.12 to 2;11.12 (*M* = 2;6.28), with a mean level of L2 exposure at 36% (*SD* = 8%, *Range* = 22% – 50%). Eighty-two percent of mothers held a University degree.

Materials

Language Exposure Assessment Tool (LEAT). This questionnaire has been used in previous studies to measure infants' exposure to the languages that they hear (De Anda, Bosch, Poulin-Dubois, Zesiger & Friend, 2016). The experimenter conducted an interview with a parent at each wave of data collection, to ask who communicates with the child on a weekly basis (e.g., parents, educator, grandparents, etc.), what languages they speak to the child, and for how long. This data was then entered into an electronic form, and an estimate of the proportion of time that the child is exposed to each language was then calculated at 1;4, 1;10, and 2;6 respectively.

CDI: Words and Gestures. The CDI: WG is a vocabulary checklist that is completed by parents, and which measures infants' receptive and expressive vocabulary at 0;8 to 1;4. The American English (Fenson, Dale, Reznick, Thal, Bates, Hartung, Pethick & Reilly, 1993) and French Canadian (Trudeau, Frank & Poulin-Dubois, 1999) adaptations were used to measure vocabulary, with the English and French Canadian adaptations containing 396 and 408 words respectively. There are a total of 380 TE pairs on this form of the CDI.

CDI: Words and Sentences. The CDI: WS is a parent report vocabulary checklist that measures toddlers' expressive vocabulary, from 1;4 to 2;6. The English and French Canadian adaptations (Fenson et al., 1993; Trudeau et al., 1999) contain 680 and 624 words respectively, and include 548 TE pairs.

Procedure

Expert speakers (parents, grandparents, educators, etc.) who spoke to the children in each language were asked to fill out the CDI in English or French at each wave and two calculations were performed: one to obtain an estimate of the proportion of TEs including cognates (words that are similar in both spelling and sound, such as *pizza* and *pizza* or *jeans* and *jeans*) and semi-cognates (words that are similar in sound but differ slightly in spelling, such as *banana* and *banane* or *mittens* and *mitaines*) and one to obtain an estimate of the proportion of TEs excluding cognates and semi-cognates. Firstly, the total proportion of TEs including cognates and semi-cognates was calculated by summing the number of identified TE pairs on the CDIs and multiplying this score by two. This number was then divided by the child's total vocabulary minus non-equivalents (words that have no translation on the other CDI form). A second proportion excluding cognates and semi-cognates was then calculated by summing the identified TE pairs on the CDIs, subtracting all cognate and semi-cognate pairs, and multiplying by two. This number was then divided by the child's total vocabulary minus cognates, semi-cognates, and non-equivalents.

Importantly, TE pairs (including both cognates and semi-cognates) on each of the CDI forms were identified by two independent and fully bilingual raters. These raters then came to an agreement on which words from each form would be selected as pairs. They also came to a consensus on which TEs would be classified as cognate or semi-cognate pairs. Given that both the English and French forms contained a limited number of synonyms, it was decided that children would be given credit for one TE pair, even if they knew synonymous words for the same concept (e.g. *sofa* and *couch* in English and *divan* and *sofa* in French).

After completing these calculations, a one-way ANOVA was conducted to compare the total proportion of TEs at each wave, and correlations were computed to examine the relation between relative exposure, vocabulary size, and the proportion of TEs across time points. In order to investigate the impact of changes in exposure and relative vocabulary size on TE development, a hierarchical regression was also performed to determine the best predictor of change at each wave of data collection. Given that no major differences were found between analyses using the total TE proportion and analyses using the proportion of TEs minus cognates and semi-cognates, all reported statistics are taken from analyses using the total proportion of TEs. However, descriptive data has been included for the proportion of TEs with cognates and semi-cognates subtracted at each wave.

Experiment 1: Results & Discussion

At Wave 1, the proportion of TEs was calculated using data from the CDI: WG. The mean proportion of TEs in bilinguals' expressive vocabulary at 1;4 was 49% (with cognates and semi-cognates removed M = 40%). At Waves 2 and 3, however, the proportion of TEs was calculated using results from the CDI: WS. The mean proportion of TEs in bilinguals' expressive vocabulary at Wave 2 of data collection was 53% (with cognates and semi-cognates removed M = 48%), with it notably increasing to 61% (with cognates and semi-cognates removed M = 59%) by Wave 3 (see Table 6 and Figures 2 & 3). Importantly, bilinguals acquired as many new TEs from Wave 1 to Wave 2 as they did from Wave 2 to Wave 3, when considering both the total proportion of TEs at each wave, as well as the proportion of new TEs acquired across waves (i.e. new TEs divided by new words added to children's vocabulary across each 6-month period). Importantly, children significantly increased the proportion of TEs in their vocabularies by 13% between 1;4

and 2;6 (F (2,32) = 6.91, p = .003), with the proportion of TEs that infants acquired at Wave 1 being positively correlated with the same proportion of TEs measured at Wave 2 and at Wave 3 (see Table 7). This suggests that there is stability in the proportion of TEs and their rate of acquisition in children's vocabularies.

Factors influencing TE acquisition in young bilinguals

In order to examine the extent to which language exposure ratios impact TE acquisition in our sample of young bilinguals, ratios for vocabulary size and language exposure were calculated by dividing L1 raw scores by L2 raw scores for each variable (Hurtado et al., 2014). Log transformations were then applied to these ratios (with smaller values being associated with more balanced exposure and vocabulary size), and bivariate correlations were run using these relative measures (see Table 7).

Importantly, and as expected, relative exposure was correlated with relative vocabulary size at Waves 1 and 2 of data collection, with a trend toward the same result at Wave 3. Relative exposure also tended to be correlated across waves, with a trend toward the same result for relative vocabulary. This suggests moderate stability in both relative language exposure and vocabulary size over time. More importantly, both relative exposure and relative vocabulary size were correlated with the total proportion of TEs in children's vocabularies at Waves 2 and 3, such that children with more balanced ratios of exposure and vocabulary exhibited a greater proportion of TEs in their vocabulary. Although these results did not reach significance at Wave 1, the correlations were in the expected direction. Because children were only beginning to develop their productive vocabularies at this stage of development, and several children had not yet acquired TEs in their vocabularies, it is possible that there simply was not enough variability in the data to produce strong correlations at this wave.

In order to assess the impact of changes in relative exposure and vocabulary size on change in the proportion of TEs across waves, two regression analyses were conducted, one each for TE development from 1;4 to 1;10 and from 1;10 to 2;6. The first examined the predictive ability of changes in language exposure and relative vocabulary size on TE development between 1;4 and 1;10. Importantly, change in relative vocabulary size accounted for 15% of the variance in change across waves, and emerged as the best predictor in the model. Children who exhibited more balanced rates of vocabulary growth (i.e. adding approximately as many new words in L1 as they did in L2 across waves) accumulated more new TEs across waves (ΔF (1,30) = 5.66, p = .024; see Table 8). The second regression examined the predictive ability of changes in language exposure and relative vocabulary size on TE development between 1;10 and 2;6. The results once again indicated that changes in the ratio of L1:L2 vocabulary size best predicted change in the proportion of TEs across waves, such that children who exhibited more balanced rates of acquisition accumulated more new TEs (ΔF (1,31) = 24.10, $p <$ .01). Change in relative vocabulary size accounted for an additional 39% of the variance in TE acquisition across waves above and beyond change in relative exposure.

Importantly, change in language exposure accounted for only 3% of the variance in TE development from Wave 1 to Wave 2, and 10% of the variance from Wave 2 to Wave 3. Although change in exposure did not emerge as a significant predictor of change in the proportion of TEs from 1;4 to 1;10 and from 1;10 to 2;6 on its own, it was a significant predictor of such changes across 1;10 and 2;6 when change in relative vocabulary size was also taken into account.

These results suggest that although change in relative language exposure is a moderating factor in the model, it is the ratio of words learned that has the greatest

impact on TE development. The fact that having a more balanced rate of vocabulary acquisition was predictive of TE development across each 6-month period is to be expected, as it provides more opportunities to acquire TE pairs. However, the fact that language exposure per se is not a significant predictor of this development suggests that it is children's ability to utilize the input in their environment to learn new words that matters the most with respect to TE development.

Although change in relative exposure was significantly correlated with change in relative vocabulary from 1;4 to 1;10 (r (32) = .38, p = .03), this was not the case from 1;10 to 2;6 (r (32) = -.21, p = .31). This suggests that there may be more inherent error in parents' report of language exposure or vocabulary size at Wave 3, perhaps due to more children entering day care or pre-school settings.

Experiment 2: Methods

The purpose of this second experiment was to compare a direct measure of children's TE comprehension with parent report of the same subset of words. We conducted this experiment to test the hypothesis that parents might under or over report TE comprehension.

Participants

Participants were recruited through birth lists provided by a governmental health agency in Montréal, Canada. Once again, in order to be eligible for each study, bilingual participants were required to be French-English bilinguals from birth, and needed to have at least 20% exposure to their second language. Exposure to a third language, if any, was below 10%. A total of 22 bilingual participants were tested. Out of these 22 toddlers, 2 were excluded due to missing vocabulary measures. The final sample consisted of 20 simultaneous French-English bilingual toddlers (11 females and 9 males) ranging in age

from 2;0.21 to 2;5.3 (*M* = 2;2.15). The mean for second language exposure was 34% (*SD* = 9; *Range* = 20% – 48%).

Materials

Language Exposure Assessment Tool (LEAT). Language exposure was assessed in the same manner as in Experiment 1 (De Anda, Bosch, Poulin-Dubois, Zesiger & Friend, 2016).

Computerized Comprehension Task (CCT). The CCT (Friend & Keplinger, 2003) is a laboratory-based measure that assesses a child's receptive vocabulary in French and English by presenting two images simultaneously on a touch screen and asking the child to touch the target image when prompted (e.g., *Where is the chair? Touch chair.).* Test trials consisted of 40 pairs of images that were accompanied by auditory reinforcement when the child correctly touched a target image. This task is available in French, English, and Spanish, and was originally intended for monolingual children. Consequently, there were very few pairs of TEs incorporated into the original English and French CCT adaptations. Therefore, this task was adapted to obtain versions that would contain only words with the same meaning in both languages (e.g. *diaper* in English and *couche* in French). The pairs of images consisted of nouns (22 pairs), verbs (10 pairs) and adjectives (8 pairs), and corresponded to words included on the CDI (Friend, Schmitt & Simpson, 2012). Each image appeared on the screen for seven seconds, and pairs of images were balanced for difficulty, brightness, word class, colour, and size. Additionally, the test trials differed in difficulty level (easy, moderately difficult and difficult). Word difficulty level was established based on normative parent data from the CDI: WG (Dale & Fenson, 1996). The proportion of TEs for each child was calculated by summing the total number of correctly identified TE pairs, multiplying this

number by two, and dividing by the total number of correctly identified words on the CCT in both languages. Twenty-five percent of the sample was coded by a second coder to determine inter-rater reliability. Inter-rater reliability was excellent with a Pearson correlation of .996 for the English task and .999 for the French task.

Computerized Comprehension Task Checklist (CCT Checklist). This checklist was created for the purpose of this study. There is an English as well as a French version, both of which include the same set of words included in the adapted CCT. There are 40 words on each checklist and parents were asked to check off words that their child comprehends. Ninety percent of parents who completed the CCT checklist spoke both English and French.

Procedure

Parents and children came in for two visits, scheduled approximately one week apart. On the first visit, there was a warm-up period for the child to become acquainted with the experimenter. During this period, the experimenter explained the study, and parents were asked to read and sign the written consent form. Afterwards, parents were asked to complete the CCT Checklist in both English and French. Upon completion of the questionnaires, the experimenter administered either the French or the English CCT. The initial language of testing for this task was counterbalanced across children. Before starting the CCT, the child was seated on his/her parent's lap, in order to be able to reach the screen. Parents were also asked to wear a pair of darkened glasses to prevent inadvertently cuing their child during administration of the CCT. On the second visit, the experimenter administered the CCT in the language that was not administered on the first visit. Parents were compensated with $20, and toddlers received a gift at each visit in addition to a certificate of merit.

Experiment 2: Results & Discussion

The results from the present study suggest that parents tend to over-report the number of TEs in their child's vocabulary. Parents reported that children had significantly more TEs on the CCT checklist than children showed knowledge of on the CCT (t (19) = 2.49, p = .02; see Table 9). That is, parents reported that their children knew on average 16% more TEs than they showed comprehension of on a direct measure of receptive vocabulary. Importantly, although TEs on the CCT were not significantly correlated with parents' report of children's TE comprehension, the correlation was in the expected direction (see Table 10).

In addition to investigating the convergence between the children's comprehension of TEs on the CCT and parent report, we also examined whether relative language exposure was able to predict both measures of TE development in this sample of children. Whereas a significant correlation emerged between relative exposure and parents' report of TEs, no such correlation emerged between relative exposure and TEs as measured by the CCT. Moreover, although both measures of TE acquisition were positively correlated with L2 vocabulary size, no significant correlations emerged between relative vocabulary size and the proportion of TEs.

The fact that a discrepancy was observed between parent report and a direct measure of TEs suggests that parents may experience difficulty in reporting on their child's comprehension of words across languages. Moreover, the fact that a significant correlation emerged between relative exposure and parents' report of TEs, but not between relative exposure and TEs as measured by the CCT, suggests that parents may be drawing upon their sense of children's relative language exposure in order to report on

vocabulary knowledge. Parents may also be using a more lenient criterion for comprehension than what is required of children on the CCT.

General Discussion

The main goals of the present study were to 1) investigate the development of TEs in a sample of young bilinguals across three developmental time points, 2) to examine whether relative language exposure contributes to early TE acquisition in these children, and 3) to examine the convergence of a direct measure of TE acquisition with parental report, in order to test the hypothesis that parents may be under or over reporting the number of TEs in children's vocabularies.

The results from the first experiment indicate that by 1;4, most children have TEs in their productive vocabulary, although there is a large degree of variability across children. This is in line with previous research showing that TE acquisition begins early in development, typically during the first year while children are still developing their receptive lexicons (Bosch & Ramon-Casas 2014; Byers-Heinlein & Werker, 2013; De Houwer et al., 2006; Deuchar & Quay, 2001; Genesee & Nicoladis, 2007; Holowka et al., 2002; Junker & Stockman, 2002; Nicoladis & Secco, 2000; Pearson et al., 1993; Pearson et al., 1995; Quay, 1995; Schelletter, 2002). It is important to note, however, that the mean proportions of TEs reported at 1;4, 2;0, and 2;6 in the current study are somewhat higher than what has typically been observed in the literature (approximately 30%). One possibility for this discrepancy are differences in the methodologies that have been used in the literature to measure the proportion of TEs. Four out of ten studies that have reported quantitative data on the presence of TEs in the lexicons of young bilinguals have used audiovisual recordings or diary entries to record data (Deuchar & Quay, 2001; Nicoladis & Secco, 2000; Holowka, Brosseau-Lapre & Petitto, 2002; Schelletter, 2002).

These studies, conducted with both infants and toddlers, reported means of 33%, 25%, 27% and 30% TEs respectively. The other six studies reported in the literature used parent report measures, such as the CDI and the Language Development Survey (LDS). Although Byers-Heinlein and Werker (2013) and Pearson et al. (1995) reported means of 26% and 31% TEs respectively using the CDI to measure vocabulary, Poulin-Dubois et al. (2013) reported a mean of 37% and David and Wei (2008) reported up to 40% TEs using the CDI. Moreover, Junker and Stockman (2002) reported a mean TE proportion of nearly 44% using the LDS, suggesting that the mean proportion of TEs observed in children's vocabularies may in part be a function of the measure that is used. It would appear that vocabulary checklists such as the CDI and LDS might provide more opportunities for TEs to be quantified than direct audiovisual measures and diary entries, which are dependent on children producing TEs in order for them to be quantified.

Moreover, in the present study, forty-four percent of our sample in Experiment 1 received input in their second language more than 40% of the time at Wave 1, and 35% of our sample received similar input in their second language across waves 1 and 2 of data collection. Although the quantity of second language exposure in the present study does not appear to differ significantly from other similar studies in the literature, the fact that most children had fairly balanced rates of exposure to each of their languages may have contributed to the larger proportion of TEs that was observed. This, in conjunction with the fact that most parents were bilingual, often speaking both English and French regularly, may have in turn provided these children with additional opportunities to learn TEs. Furthermore, although the official language of Montréal is French, it is predominantly a bilingual city, with children frequently being exposed to English and French both at home and in the community. Importantly, although all of these factors

may have facilitated the acquisition of TEs in our sample, it is also reasonable to believe that the means reported here are simply products of individual variability, with our sample containing children with higher overall rates of TE acquisition than what has been reported previously. However, the observed effect of relative vocabulary size on TE acquisition argues in favor of the former interpretation.

Importantly, given the longitudinal nature of the present study, we were able to show that TE acquisition appears to increase gradually along with total vocabulary size, and that rates of growth are fairly stable across the second year. By 2;0 significant relations emerged between relative exposure and vocabulary size, and the proportion of TEs in children's vocabularies. These relations showed that children with a more balanced exposure typically developed more balanced vocabulary sizes in each of their languages, which in turn facilitated the acquisition of TEs. This is in line with previous research showing that exposure can predict the proportion of TEs in children's vocabularies (David & Wei, 2008; Montanari, 2010; Pearson et al., 1995). The finding that *relative* exposure is associated with *relative* vocabulary size, however, is in line with recent reports by Hurtado and colleagues (2014). Importantly, both Hurtado et al. (2014) and Grüter et al. (2014) have suggested that correlating relative measures, such as language exposure, with raw scores, such as the number of words in a child's productive vocabulary, often distorts the relation between input and vocabulary size. To our knowledge, the present study is the first to show that TE acquisition is directly related to both relative exposure and relative vocabulary size.

In addition to examining the relation between relative language exposure, relative vocabulary size and proportion of TEs at each wave, we also aimed to investigate how changes in these aspects of vocabulary development might impact change in the

proportion of TEs across waves. Importantly, change in relative vocabulary size, as opposed to change in relative language exposure, emerged as a main predictor of TE development across waves. More specifically, more balanced rates of word growth seemed to facilitate the acquisition of TEs across each developmental time point. Furthermore, although changes in relative language exposure appeared to predict changes in vocabulary ratios across 1;4 and 1;10, this was not the case across 1;10 and 2;6. These data suggest that a greater degree of error may exist for parents' report of exposure and vocabulary size at this later developmental time point, or that factors other than language exposure may be driving children's acquisition of new words in each of their languages. Although we did not look specifically at quality of input or children's language preferences in the present study, it is possible that these factors are playing a larger role in vocabulary growth at this stage of development.

The second experiment in this study aimed to examine the convergence of a direct measure of TE comprehension and parent report of the same subset of words. To date, the majority of studies examining TE development in young bilingual children have used parent report measures, such as the MacArthur Bates CDI. Although such measures are well established as providing efficient and valid estimates of children's vocabulary development, it is possible that parents of bilingual children may have more difficulty differentiating word knowledge in each of their child's languages when reporting on these measures, ultimately leading to under or over reporting of TEs. This issue may be even more salient for parents when they are asked to report on their child's comprehension of words, as opposed to their production, which is often much more evident and explicit for parents.

Interestingly, two studies comparing parent report of word comprehension with a looking time measure in samples of monolingual infants aged 1;6 provided conflicting results. Whereas the first study of this nature showed that parents have a tendency to underestimate infants' comprehension on the CDI (Houston-Price, Mather & Sakkalou, 2007), the second study, which used the same tasks and procedure but different stimuli, found that parents are able to accurately assess infants' comprehension of words (Styles & Plunkett, 2009). Although both studies were conducted with samples of British children aged 1;6, Houston-Price et al. (2007) used known and *familiar* word pairs, and Styles and Plunkett (2009) used known and *unfamiliar* word pairs in their stimuli. Moreover, whereas Houston-Price et al. attempted to address issues such as object preference in their looking time procedure by presenting word pairs more than once, Styles and Plunkett only presented each word pair once in an attempt to determine whether the familiarity of the distracter image impacts children's looking patterns. In doing so, they found that parents' report of comprehension on the CDI was an accurate predictor of looking time. They also suggested that the threshold for which parents mark an item on the CDI as understood is when an infant is able to correctly identify the target with only one presentation, in an unfamiliar environment and in the presence of potentially confusing distracters (pp. 907; Styles & Plunkett, 2009).

Although lexical targets were tested only once on each form of the CCT, target images also appeared as distracter images throughout the administration. In theory, this has the potential to inflate children's vocabulary scores through use of the mutual exclusivity bias (although this did not appear to be the case, as our children did not reach ceiling on this task). Nevertheless, parents were observed to over-report infants' vocabulary comprehension, similar to what was observed for an alternate sample of

bilinguals aged 1;4 who were administered the original version of the CCT (Legacy et al., 2016). Although it is possible that the CCT may be underestimating receptive vocabulary scores in this experiment, it is unlikely. It is possible that the over-reporting of TEs in Experiment 2 is indicative of parents confounding their child's dominant and non-dominant languages when reporting on comprehension. However, it is also possible that parents may be picking up on children's partial comprehension of words. Unlike parent report, the CCT removes context from the assessment of children's understanding of words, which means that partial mappings of words that are still largely dependent on context and have not yet been generalized, are likely not accounted for in children's accuracy scores on this task. That is, parents may observe behavioural markers of these contextually based partial mappings, but children are unable to generalize this basic understanding on measures such as the CCT, which removes contextual cues. A recent study comparing looking time measures with touching behaviour on the CCT showed that children's responding reflected these partial mappings, with a full mapping typically being characterized by a correct touch to the target, a partial mapping typically characterized by a look to the target but a touch to the distractor, and no mapping characterized by the infant refraining from touching the screen (Hendrickson, Mitsven, Poulin-Dubois, Zesiger & Friend, 2014). As a result, it is possible that Houston-Price and colleagues are picking up on these partial mappings in their study due to using only familiar items. Moreover, as mentioned by Styles and Plunkett (2009), it is unclear how exactly parents define comprehension of a particular word when completing the CDI. They also, however, suggest that whereas British parents appeared to be using the threshold stated above, parents from other countries may not be as stringent in their criteria for what constitutes comprehension. This was also suggested by Houston-Price

and colleagues (2007), who noted that there is research that indicates that North American parents may be more likely to over-report children's word knowledge on the CDI (Hamilton, Plunkett & Schafer, 2000; Tomasello & Mervis, 1994). The fact that CDI reporting of comprehension appears to differ to some extent based on parental definition of word understanding and other cultural factors emphasizes the importance of using direct measures of early vocabulary comprehension in conjunction with parent report to acquire a much more comprehensive understanding of early vocabulary development and TE acquisition in young bilinguals.

In addition to investigating the convergence between the children's comprehension of TEs on the CCT and parent report, we also examined whether relative language exposure was able to predict both measures of TE development in this sample of children. Interestingly, whereas a significant correlation emerged between relative exposure and parents' report of TEs, no such correlation emerged between relative exposure and TEs as measured by the CCT. However, of note is the fact that children's performance on the CCT did not correlate with parents' reports of the same subset of words. This discrepancy may reflect the small sample of words on the CCT in relation to larger vocabulary inventories such as the CDI. However, it may also be due to the fact that exposure ratios are calculated based on reports from parents regarding their language use. It is likely that parents use these estimates to guide their own reporting of children's word knowledge and in this case TEs.

Conclusion & Future Directions

In sum, the present study shows that the acquisition of TEs is a gradual process that coincides with early bilingual vocabulary development. It also provides evidence for the relation between quantity of language exposure and TE development, but shows that

the ratio of L1 to L2 vocabulary is a better predictor of TE development than L2 exposure in young bilinguals. Lastly, to our knowledge, this is the first study to compare a direct measure of TE comprehension with parent report during the second year of life. The findings from this comparison emphasize the necessity of using multiple measures of early vocabulary development, including both direct and indirect measures, to advance our understanding of TE acquisition early on in development.

No doubt, there are several limitations to the present study. Although we were able to examine the relation between quantity of language exposure and TE development in Experiment 1, future research is required to determine how other input factors, such as context and quality of input, shape the acquisition of TEs in early bilingual development. Moreover, this experiment should be replicated with other languages and cultures to determine if the same pattern of development holds for multiple samples of bilingual children. The small sample size in Experiment 2 was also a limitation to this study, and as a result, this experiment should be repeated with larger samples of children. Replicating this experiment with children learning different languages in different cultures may also shed light on whether the parent report discrepancy observed in this study is linked to cultural factors, as has been previously suggested in the literature.

Table 6. Mean productive vocabulary, language exposure, and TE scores at each wave of data collection.

	Wave 1			Wave 2			Wave 3		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
L1 Vocabulary	51.44	46.33	0 – 208	230.85	165.09	4 – 643	427.59	146.52	109 – 635
L2 Vocabulary	39.32	45.53	0 – 238	146.35	110.36	4 – 446	252.56	167.56	34 – 680
Relative Vocabulary	.37	.76	-1.17 – 1.70	.48	.73	-.94 – 1.87	.72	.72	-.22 – 2.26
L1 Exposure	.64	.09	.51 – .78	.64	.10	.50 – .79	.64	.08	.50 – .78
L2 Exposure	.36	.08	.22 – .48	.36	.10	.21 – .50	.36	.08	.22 – .50
Relative Exposure	.57	.37	.08 – 1.27	.62	.45	0 – 1.32	.58	.36	0 – 1.27
Proportion TEs	.49	.16	0 – .74	.53	.16	.26 – .89	.61	.22	.22 – .97
Proportion TEs (minus cognates + semi cognates)	.40	.19	0 – .72	.48	.19	0 – .87	.59	.23	.16 – .97

Table 7. Bivariate correlations between relative exposure and vocabulary size and the proportion of TEs at each wave (N = 34).

	W1 Relative Vocabulary	W2 Relative Vocabulary	W3 Relative Vocabulary	W1 Relative Exposure	W2 Relative Exposure	W3 Relative Exposure	W1 TE	W2 TE	W3 TE
W1 Relative Vocabulary	---	.31 p = .08	.36 p = .04	.50** p < .01	.09 p = .63	.18 p = .31	-.15 p = .41	.04 p = .82	-.35 p = .05
W2 Relative Vocabulary		---	.29 p = .09	.13 p = .46	.52** p < .01	.48** p < .01	-.19 p = .27	-.51** p < .01	-.24 p = .17
W3 Relative Vocabulary			---	.16 p = .35	.31 p = .07	.30 p = .09	-.44** p < .01	-.36 p = .04	-.91** p < .00
W1 Relative Exposure				---	.32 p = .07	.30 p = .08	.16 p = .36	-.02 p = .91	-.13 p = .45
W2 Relative Exposure					---	.54** p < .01	-.06 p = .76	-.42* p = .02	-.20 p = .27
W3 Relative Exposure						---	-.24 p = .17	-.30 p = .08	-.43* p = .01
W1 TE							---	.48** p < .01	.49** p < .01
W2 TE								---	.37 p = .03
W3 TE									---

Note. * indicates significance using a False Discovery Rate adjusted alpha for multiple comparisons (Benjamini & Hochberg, 1995).

Table 8. Multiple regression models (standardized Betas) with change in L1:L2 ratios of language exposure and vocabulary size as predictors of TE growth across each 6-month period (Wave 1-2 and Wave 2-3).

	TE Growth			
	Waves 1-2		Waves 2-3	
Predictors	Model 1	Model 2	Model 1	Model 2
Relative language exposure	-.16	.11	-.32	-.27*
Relative vocabulary	---	-.48*	---	-.63**
Total R^2	.03	.15	.10	.39

*p < .05; **p < .01

Table 9. Mean vocabulary scores and the proportion of TEs in Experiment 2.

	Mean	SD	Range
L1 Vocabulary (CCT)	30.15	7.23	12 – 39
L2 Vocabulary (CCT)	24.15	7.71	9 – 38
Proportion of TEs (CCT)	.52	.24	.10 – .90
L1 Vocabulary (Vocabulary Checklist)	35.00	7.03	8 – 40
L2 Vocabulary (Vocabulary Checklist)	28.45	9.22	11 – 40
Proportion of TEs (Vocabulary Checklist)	.68	.27	.05 – 1.0

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

Table 10. Bivariate correlations between relative exposure, vocabulary size, and the proportion of TEs in Experiment 2.

	TEs (CCT)	TEs (Checklist)	Relative Exposure	CCT L2 Vocabulary	CCT Relative Vocabulary
TEs (CCT)	---	.41 p = .08	-.25 p = .28	.94** p < .01	-.28 p = .23
TEs (Checklist)		---	-.52* p = .02	.46* p = .04	-.38 p = .10
Relative Exposure			---	-.31 p = .19	.35 p = .14
CCT L2 Vocabulary				---	-.58* p = .01
CCT Relative Vocabulary					---

* p < .05
** p < .01

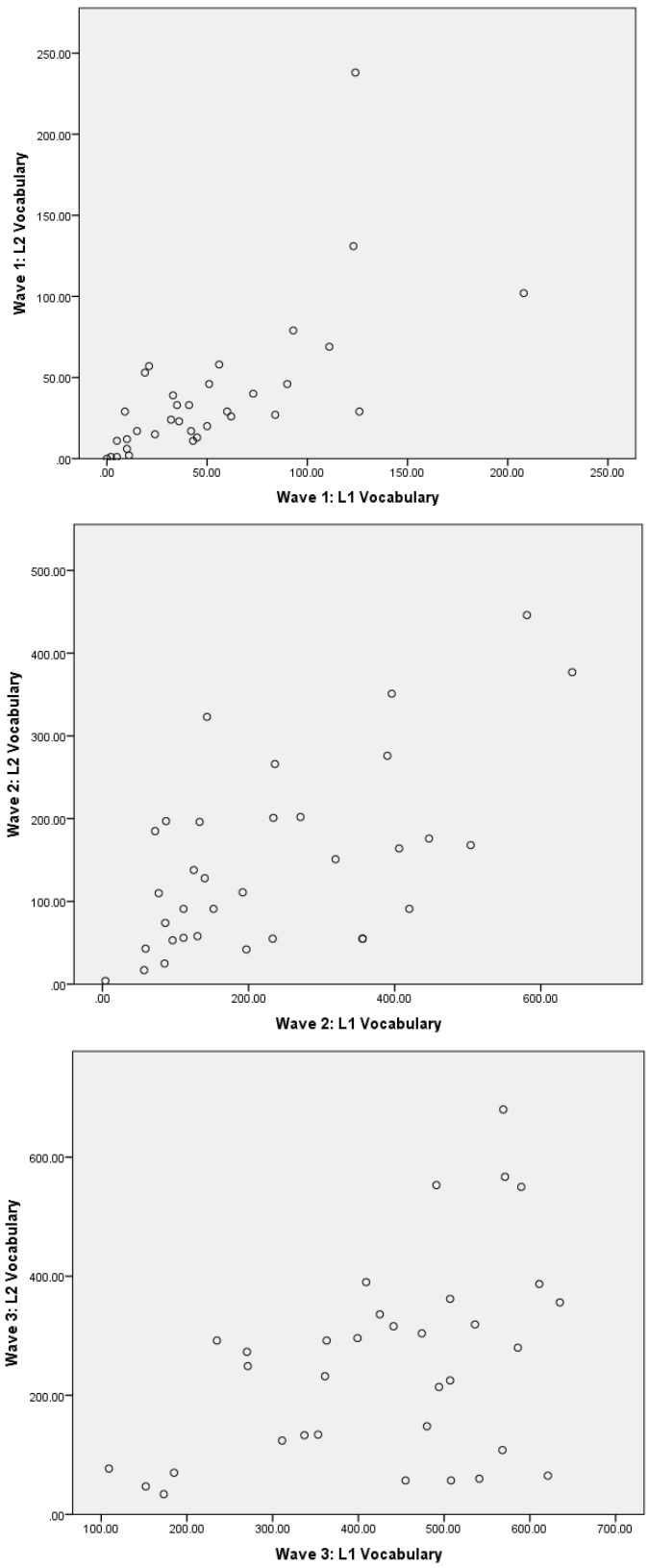

Figure 2. Individual variability in L1 and L2 vocabulary size at Waves 1, 2 & 3.

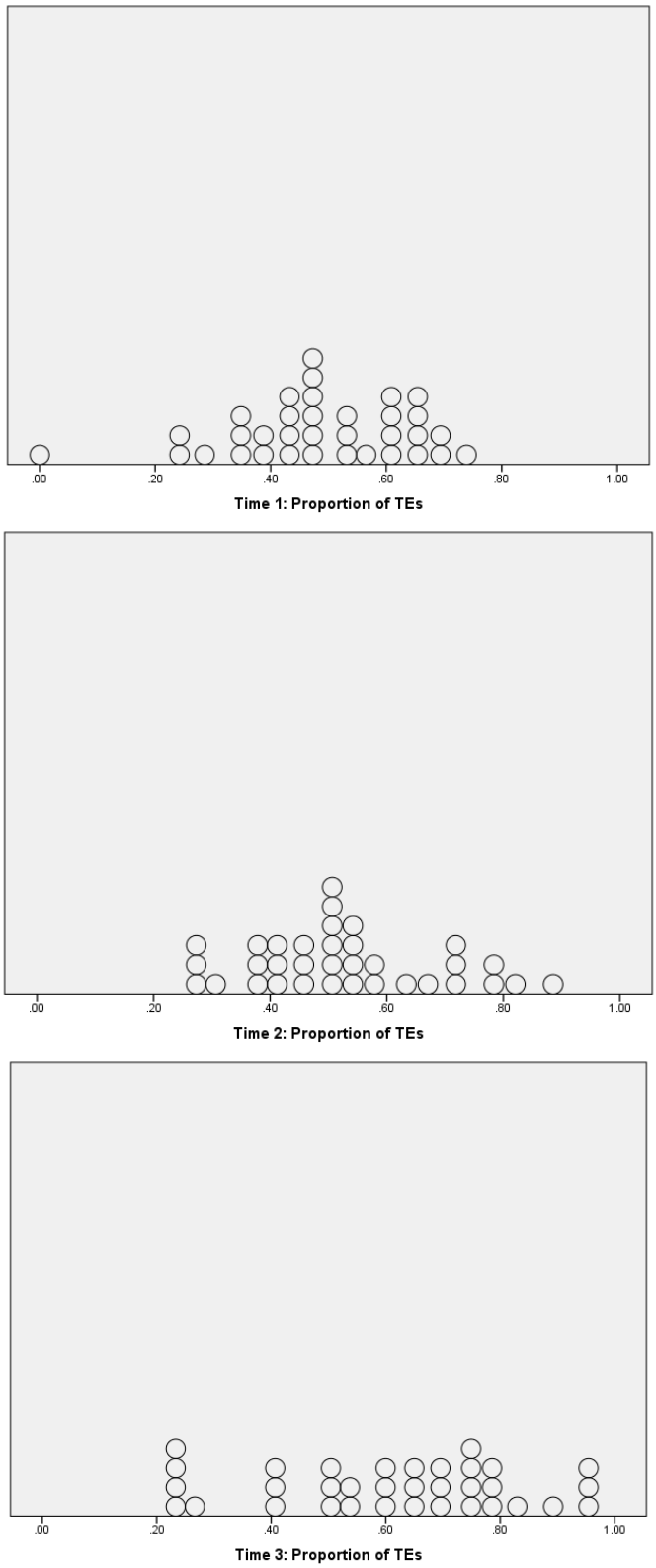

Figure 3. Individual variability in the proportion of TEs across waves.

Chapter 5

General Discussion

To date, research on early bilingualism has relied heavily on indirect measures of receptive and expressive vocabulary, such as parental report. Moreover, the majority of studies examining continuity in vocabulary development and lexical access in very young bilinguals have been cross-sectional in nature. With this in mind, each of the manuscripts included in this dissertation has aimed to address these significant gaps in the bilingualism literature.

Direct and indirect measures of vocabulary development

A main goal of this dissertation was to longitudinally examine the receptive and expressive vocabulary development of a sample of very young bilingual children using both direct and indirect measures of vocabulary growth. The data from the studies presented here are consistent with a growing body of literature that suggests that bilingual vocabulary development is similar in many ways to that of monolinguals. However, it is also clear that developmental patterns are to some extent dependent on whether vocabulary comprehension or production is being considered, and whether direct or indirect measures are used to quantify vocabulary growth.

Vocabulary comprehension. Although the 16-month-old bilingual children included in this dissertation exhibited individual receptive vocabularies that were smaller than that of their monolingual peers when data from the CCT was considered, their total vocabulary size was on par with children learning only one language. Interestingly, a similar patter emerged on the CDI, with the bilinguals being able to keep pace with the monolinguals in their dominant, but not their non-dominant language. Furthermore, over the following six months, bilingual comprehension levels shifted on the CCT to mirror this finding, such that children were able to keep pace with their monolingual peers in their L1, but exhibited a significantly smaller vocabulary size in L2.

As we saw in manuscript one, although the CCT and CDI were correlated at 16-months, differential patterns emerged with respect to vocabulary size in L1 and L2 on these measures. Whereas a significant difference emerged between L1 and L2 on the CDI at this stage of development, only a trend existed for vocabulary on the CCT. It was not until 22-months that a significant difference fully emerged between L1 and L2 on the CCT for the bilinguals. Although this discrepancy may have in part been due to the fact that the CCT contains a much smaller subset of words than the CDI, it may also reflect a true difference between children's decontextualized word knowledge and their word knowledge within a given context. Although parents may observe behavioural markers of partial word mappings at home, children may be unable to display their word knowledge on explicit tasks that require them to generalize their understanding to an unfamiliar exemplar in an unfamiliar context. This difference between the level of knowledge required to succeed on explicit vocabulary tasks such as the CCT and the level of knowledge required to exhibit behavioural markers of a partial word mapping in a given context, may result in discrepancies between *parent report* of children's comprehension and *direct measures* of children's comprehension. Indeed, research conducted by Hendrickson and colleagues (2015) on looking and touching behaviours on the CCT suggests that correct, incorrect, and missing trials may represent a gradient of word knowledge, with correct trials representing complete word mappings, incorrect trials representing partial word mappings, and no-touch trials representing a lack of word knowledge. As a result, it is reasonable to assume that receptive word knowledge may exist on a continuum, from weak to strong, and that children may require multiple exposures before that knowledge is strong enough to be generalized to an unfamiliar context.

Interestingly, in manuscript three, this discrepancy between parent report and the CCT again emerged with respect to TE development in a separate sample of 24-month-old bilingual children. Parents reported that children comprehended 16% more TEs than they displayed knowledge of on the CCT. Although it is difficult to determine which measure is more accurate in this case, the fact that a discrepancy once again exists across measures suggests that perhaps parent report checklists and direct measures of vocabulary comprehension are measuring somewhat different constructs. That is, parent report checklists may provide accurate estimates of a wide range of vocabulary (which can consist of both generalized and non-generalized word mappings), and direct measures may provide accurate estimates of *decontextualized vocabulary* (which consists of solidified, or generalized word mappings). In essence, these data emphasize the importance of utilizing both direct AND indirect measures of early vocabulary comprehension in order to acquire a more complete understanding of receptive vocabulary development in very young bilinguals.

Vocabulary production. As in monolingual development, bilingual vocabulary production is preceded by extensive receptive vocabulary development. Children begin to understand the language in their environment long before they ever begin to produce it, and as such, understanding the similarities and differences between receptive and expressive vocabulary development can aid us in understanding how bilingual children go about acquiring each of their languages. The synthesis of data presented in manuscript two included expressive vocabulary measures in the form of the CDI administered at both 16 and 22 months of age. At 16 months of age, both the bilinguals and the monolinguals had only begun to build their productive vocabularies. Whereas the bilinguals were able to produce more words in their L1 compared to their L2, they did not significantly differ

from the monolinguals with respect to production in either of their individual languages, and when L1 and L2 were combined to create a measure of total vocabulary, it appeared that the bilinguals were able to produce significantly more words than the monolinguals. At 22 months of age, however, this difference between bilingual composite measures of vocabulary and monolingual scores on the CDI disappeared, and the monolinguals surpassed the bilinguals with regard to production in L2.

Interestingly, these results suggest a pattern of development that is initially quite similar to that of monolingual development. At 16-months, the bilinguals kept pace with their monolingual peers in each of their respective languages, and even surpassed them with respect to total vocabulary. However, by 22-months, we see the gap widen for L2 vocabulary, such that the bilinguals were only able to keep pace with the monolinguals in their dominant language. Moreover, we see similar total vocabulary sizes for both groups at this stage of development. Importantly, the gap observed between L1 and L2 expressive vocabulary size at 22-months was also observed in children's receptive vocabulary on the CDI at 16-months. Furthermore, although we did not re-asses children's comprehension using parent report measures at 22-months, a similar finding was observed for the bilinguals on the CCT. This suggests that although there may be somewhat less convergence between receptive and expressive vocabulary development at the earliest stages of acquisition, by the end of the second year, a clear pattern seems to emerge with respect to L1 and L2 vocabulary development, at least for the present sample of children.

Language exposure

Importantly, although quality of exposure was not investigated in this dissertation, quantity of exposure continually emerged as an important predictor of vocabulary size

and growth across waves. Although the gap between L1 and L2 receptive and expressive vocabulary development was statistically evident in the present sample of bilinguals by 22-months, it is important to note that relative vocabulary ratios appeared to be driven in part by relative language exposure. Relative language exposure at 16-months for example was found to significantly predict receptive and expressive vocabulary size at 22-months. Interestingly, early experience with dual language input appears to set the stage for receptive and expressive vocabulary development, such that differences in L1 and L2 *comprehension* emerge early on in development and are maintained over time, despite similar rates of growth in each language. For the French-English bilinguals included in this dissertation, similar patterns were observed for vocabulary *production*, however children tended to acquire somewhat fewer new words in their L2 over time. These findings again speak to the relation between early language exposure and word learning in each language, and emphasize the importance of experience in the non-dominant language early in development.

Although strong relations have been reported between quantity of language exposure and vocabulary size, both in this dissertation and in the bilingualism literature at large (De Houwer, 2007; De Houwer, Bornstein & De Coster, 2006; Hoff, 2013; Hoff & Core, 2013; Hurtado, Grüter, Marchman & Fernald, 2014; Pearson et al., 1997; Place & Hoff, 2011), research to date has shown inconsistent links between quantity of language exposure and TE development (Byers-Heinlein & Werker, 2013; David & Wei, 2008; Lanvers, 1999; Montanari, 2010; Pearson et al., 1995; Poulin-Dubois et al., 2013). In manuscript three, it was found that although changes in relative language exposure accounted for a portion of the variance in children's TE acquisition, it was change in relative vocabulary that was the best predictor at this stage of development. This suggests

that although exposure to a given language is necessary for vocabulary development to occur, when it comes to TEs, it is children's ability to process and utilize this input that best predicts TE acquisition. As expected, children who acquired similar numbers of new words in each of their languages exhibited increased rates of TE acquisition across waves. However, there was also a great deal of variability across children in this respect, which suggests that other factors, such as quality of exposure and child language preference, may also play a significant role in shaping TE acquisition. Indeed, it is not unreasonable to assume that some parents may provide additional opportunities for their children to learn TEs compared to other parents. Bilingual parents may especially provide their child with labels in each language for a given object or action, aiding children in their ability to accept multiple labels for the same concept. Although further research comparing the impact of quantity and quality of exposure on children's TE acquisition would be required to confirm this notion, there is recent research to suggest that both quantity and quality of language exposure are associated with children's willingness to accept more than one label for an object. This research, conducted with 3-, 4-, and 5-year-old English-Spanish speaking children, found that for English dominant children, even minor increases in the quantity of Spanish exposure were related to children's willingness to accept multiple labels for a novel object (Rojo & Echols, 2016). Moreover, Spanish exposure uniquely provided by extended relatives and teachers was shown to be the best predictor of children's willingness to accept multiple labels, indicating that there is something unique about the *quality* of this exposure (in contrast to Spanish exposure provided from other sources) that may potentially facilitate the acquisition of TEs in these children (Rojo & Echols, 2016). Although this research was conducted with preschoolers and did not directly measure the proportion of TEs in children's

vocabularies, it has important implications for our understanding of the factors that might influence TE acquisition in young bilinguals.

Word processing speed

A main goal of this dissertation was to investigate the role that processing speed plays in early bilingual vocabulary development. In monolingual children, processing speed has been linked to vocabulary size, such that children who are better at online processing of words typically have larger vocabularies (Fernald, Marchman & Weisleder, 2013; Fernald, Perfors & Marchman, 2006; Hurtado, Marchman & Fernald, 2007; Hurtado, Marchman & Fernald, 2008; Marchman & Fernald, 2008). To date, the majority of studies examining online processing of words in young bilingual children have used the LWL procedure, which tracks children's eye gaze as they are prompted to attend to a familiar target on screen. These studies have reported significant within-language relations between processing speed and vocabulary size, such that children who were faster to respond to trials on the LWL task at 18-months were also the children who experienced the most vocabulary growth over the following year (Marchman et al., 2010). Importantly, significant relations have also emerged between relative exposure, relative vocabulary size, and relative processing speed in young bilinguals (Hurtado et al., 2014), which suggests that it is children's ability to process and make use of the input in their environment that helps them to grow their emerging lexicons. However, the reverse may be true as well; as children acquire new words and build their vocabularies, they may also become better able to process linguistic input in their environment as they create and clarify semantic connections between concepts and words. Regardless of the directionality of this effect, it is clear that these processes work in tandem to facilitate language acquisition in very young bilinguals.

Importantly, the findings reported in this dissertation shed light on the relations between these factors. At both 16 and 22 months, the French-English bilinguals were as fast at online processing of words in L2 as they were in L1, with children significantly increasing their processing speed across waves. Moreover, no differences in RT were observed between the bilinguals and the monolinguals at either time point. This is one of the first studies to examine online processing in very young bilinguals using a direct measure other than the LWL procedure in conjunction with a longitudinal design. Interestingly, we replicated the within-language findings previously observed in the literature between processing speed and receptive vocabulary using data from the CCT. However, cross-language relations were also observed for vocabulary in L1 and L2 at 16-months, and vocabulary and RT in L1 and L2 at 22-months. Furthermore, RT in L1 was significantly correlated with receptive vocabulary on the CCT in L2 at 22-months, such that children who were faster at processing words in L1 exhibited larger vocabularies in their non-dominant language (the relation between RT in L2 and CCT in L1 was not significant but was in the expected direction). These cross-language relations between vocabulary size and RT are in contrast to what has been previously found in the literature, and suggest that there is some degree of transfer between languages early on in bilingual development. Interestingly, in a recent study examining priming effects in 30-month-old bilingual toddlers, significant within- and cross-language priming effects were detected; however, cross-language priming effects were only observed when the prime was presented in the child's dominant language, not the reverse (Sing, 2014). Vasilyeva and colleagues (2010) found similar results in a sample of 5-year-old French-English bilingual children, as did Yip and Mathews (2000) in a case study of a bilingual child from one to three years of age. Although these studies only found cross-language transfer

from L1 to L2 or minimal transfer from L2 to L1 (a finding that is paralleled in the adult literature; Altarriba 1992; Basnight-Brown & Altarriba, 2007; Gollan, Forster, & Frost, 1997; Grainger & Frenck-Mestre, 1998; Jiang, 1999; Keatley & de Gelder, 1992; Keatley, Spinks, & de Gelder, 1994; Tzelgov & Ebenezra, 1992) there is limited research examining cross-language relations between vocabulary size and RT in bilingual children during the second year. As a result, it is possible that transfer may be bi-directional in nature at the earliest stages of vocabulary development when children are just beginning to build their vocabularies.

Conclusion

In sum, the data presented in this dissertation provides unique information about early bilingual vocabulary development. The manuscripts included in this dissertation incorporated both direct and indirect measures of receptive and expressive vocabulary acquisition, with two out of the three manuscripts using a longitudinal design to assess children's progress during a critical period of development.

The findings from these studies corroborate recent evidence suggesting that bilingual vocabulary development is similar in many ways to that of monolinguals. They also emphasize the importance of using both direct and indirect measures to acquire a more comprehensive understanding of the path that young bilingual children take to learn language.

Importantly, this was the first study to fully utilize the CCT with a bilingual population, and as such, it provides important data on the ability of the CCT to predict language outcomes in bilingual children. The CCT exhibited good convergent validity with the CDI for the present sample of French-English bilinguals, and receptive vocabulary scores showed continuity across 16 and 22-months. Processing speed on the

CCT at 16 months was also found to predict receptive vocabulary growth on the CCT at 22-months, emphasizing the ability of the CCT to predict later language outcomes.

Lastly, this dissertation highlights the relations between language exposure, online processing of words, and vocabulary growth during the second year, and shows that these internal and external factors play a critical role in shaping the emerging lexicons of bilingual children even at the earliest stages of vocabulary development.

Limitations & Future Directions

No doubt, there were several limitations to the present set of studies. One such limitation was the small sample size included at each wave of data collection. Given that recruitment for the bilingual sample took place in Montreal, a large multicultural city, it was very difficult to find children who met the strict language requirements of the study (i.e. French and English language learners with a minimum of 20% exposure to L2 and *less than 10% exposure to an L3*). Moreover, given that the bilinguals were required to attend two separate testing sessions at each wave, some children did not attend all visits or were missing data. This was compounded by the fact that some children who met the language criteria at Wave 1 of the study no longer met these requirements at Waves 2 or 3 of data collection. These inherent issues associated with recruiting and testing a bilingual sample of young children in a multicultural city made for smaller cross-wave samples and reduced power.

As second limitation to the present set of studies is the lack of parent reported comprehension at Waves 2 and 3 of the study. Although it would have been ideal to track both comprehension and production using parent report across all three waves of the study, the CDI: WG is only designed for children 8 to 16 months of age. This limitation in age range resulted in a switch from the CDI: WG to the CDI: WS (which contains

more words) at Wave 2 of the study. Although none of the children reported in this dissertation reached ceiling on the CDI: WG or CDI: WS, the growth reported across waves may have been inflated to some extent due to this change in measures.

Lastly, because the CCT was originally designed for monolingual children, the version used at Waves 1 and 2 of the Path to Literacy Project contained very few TEs. Although we attempted to address this problem by creating a French-English adaption of the CCT and running a separate study on TE development with a sample of 24-month-old bilinguals, it would have been beneficial to also have this data for our longitudinal sample of children. As a result, our understanding of TE development in this sample of children is limited to data derived from the CDI, which is predominantly production data.

Although the present set of studies contributes important information on early bilingual vocabulary, it also highlights the need for more longitudinal studies incorporating both direct and indirect measures of vocabulary development in the literature. The present set of studies should also be replicated with samples of children from other cultural, linguistic, and socioeconomic backgrounds in order to determine whether these developmental patterns are generalizable to other populations of bilinguals.

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Appendix A: Recruitment Materials

Recruitment letter for new participants (Wave 1)

Recruitment letter for new participants (CCT TE study)

August 2012

Dear parents,

The Cognitive and Language Development Laboratory, part of the Center for Research in Human Development at Concordia University, is presently involved in a study examining children's development from early word understanding through preschool. Our research has been funded by federal and provincial agencies for the past twenty-five years and our team is internationally recognized for its excellent work on early child development. Our articles are frequently published in prestigious journals such as "Infancy" and "Developmental Science" and "Enfance". You might also have heard about our studies on national radio or on the Discovery Channel.

The Commission d'Accès à l'Information du Québec has kindly given us permission to consult birthlists provided by the Régie Régionale de la Santé et des Services Sociaux de la Région de Montréal-Centre. Your name appears on the birthlist of March 2011, which indicates that you have a child of an age appropriate for our study. You and your child could help us learn about early language and how it is related to school-readiness and literacy just prior to preschool. With your help, we may be able to better identify children who need extra support in making the transition to school. This research project is funded by the National Institute of Health (US) and is conducted in collaboration with colleagues from Universities in San Diego and Geneva.

The project will take place over the next 3 years, and you and your child will visit our laboratory for a total of 7 visits scheduled at your convenience about every 6 months. The first visit will take place when your child is 16 months of age and the last one when he or she is 54 months. If your child is bilingual, we will ask you to come twice for each time point so that we can perform the tasks with your child in English and French. During each approximately 1 hour long visit, your child will be asked to point to pictures that represent words, shapes, numbers, and colors. On some visits, your child will see pictures on a computer screen and on others, s/he will see pictures in a book. Your child will do some activities to assess some developmental changes, and we will ask you to complete surveys of your child's language. During all tasks, your child will be sitting in a child seat and you will be seated directly behind. We will videotape the entire session and all tapes will be treated in the strictest of confidentiality.

Overall, your participation will involve seven 40-60 minute visits to our laboratory at the Loyola Campus of Concordia University, located at 7141 Sherbrooke Street West, in Notre-Dame-de-Grace. Appointments can be scheduled at a time that is convenient for you and your child, including weekends. Free parking is available on the campus and we offer babysitting for siblings who come to the appointment. Upon completion of each visit, you will be offered a financial compensation of 25$, and a Certificate of Merit for Contribution to Science and a small toy will be given to your child. **A summary of the results on your child's language tests will be mailed to you after each visit, and a summary of the results of the entire study will be mailed to you once it is completed.**

For the purposes of this study, we are looking for infants who are 16-18 months of age, who are **bilingual from birth in English and French**, who were not premature at birth, and who do not have any visual or hearing difficulties. If you are interested in having your child participate in this study, or would like any further information, please contact Katherine Gittins at (514) 848-2424 ext. 2279, or Dr. Diane Poulin-Dubois at (514) 848-2424 ext. 2219. For more information on our studies, please visit our website at http://crdh.concordia.ca/dpdlab/. We will try to contact you by telephone within a few days of receiving this letter. We are looking forward to speaking with you in the near future.

Sincerely yours,

Diane Poulin-Dubois, Ph.D.
Professor
Department of Psychology

Monyka Rodrigues, B.A.
Laboratory Coordinator
Department of Psychology

January 2015

Dear Parents,

The Cognitive and Language Development Laboratory, which is part of the Center for Research and Human Development at Concordia University, is presently conducting a study on bilingual infants' early language and cognitive development. If you have participated in a study in the past, we would like to thank you for your enthusiasm and commitment to research. Our research has been funded by federal and provincial agencies for the past twenty-five years and our team is internationally recognized for its excellent work on early child development. Our articles are frequently published in prestigious journals, such as "Infancy" and "Developmental Science". You also might have heard about our studies on national radio or on the *Discovery Channel*.

The Commission d'Accès à l'Information du Québec has kindly given us permission to consult birth lists provided by the Agence de la santé et des services sociaux de Montréal. Your name appears on the birth list of December 2012 or January 2013, which indicates that you have a child of an age appropriate for our study. We therefore invite you to participate in one of our new studies and have the unique experience of learning more about your child and child development, as well as contributing to research in this field!

The present investigation involves a few short tasks during which your child will interact with the experimenter. Language comprehension will be administered with a computerized task that requires your child to touch on a computer screen the image that corresponds to a word. Other tasks will measure selective attention and cognitive flexibility. For example, your child will be asked to put balls in buckets. In another game, a snack will be placed under a clear cup and your child will be asked to follow the instructions to obtain it. During all tasks, your child will either be sitting on your lap or sitting in a child seat while you are seated directly behind him/her. We will videotape your child's responses and all tapes will be treated in the strictest of confidentiality.

Overall, your participation will involve **2 visits**, approximately **30-45 minutes** each, to our laboratory at the Loyola Campus of Concordia University, located at 7141 Sherbrooke Street West, in Notre-Dame-de-Grace. Appointments can be scheduled at a time which is convenient for you and your child, including weekends. Free parking is available on the campus and we offer babysitting for siblings who come to the appointment. Upon completion of the study, a Certificate of Merit for Contribution to Science and a small gift will be given to your child, and you will be offered a financial compensation of **$40** for participating. A summary of the results of our study will be mailed to you upon its completion.

For the purposes of this study, we are looking for bilingual toddlers who are **24-26 months of age**, who are **exposed to English and French**, and who do not have any visual or hearing difficulties. All our studies are independent, so you may choose to participate once, or several times. If you are interested in having your child participate in this study, or would like any other information, please contact Josée-Anne Bécotte at (514) 848-2424 ext. 2279, or Dr. Diane Poulin-Dubois at (514) 848-2424 ext. 2219. You can also visit our website at http://crdh.concordia.ca/dpdlab. As we are very interested in having you participate, we will try to contact you by telephone within a few days of receiving this letter. We look forward to speaking with you in the near future.

Sincerely,

Diane Poulin-Dubois, Ph.D.
Professor
Department of Psychology

Josée-Anne Bécotte, B.Sc.
Laboratory Manager
Department of Psychology

Appendix B: Consent Forms

Concordia University consent form (Wave 1)

Concordia University consent form (Wave 2)

Concordia University consent form (Wave 3)

Concordia University video consent form (Waves 1-3)

Concordia University consent form (CCT TE study)

General Consent Form to Participate in Research

Concordia University
Researcher: Dr. Diane Poulin-Dubois
Protocol: The Path to Literacy

You are being asked to allow your child to participate in a research study. Before you give your consent to let your child be a volunteer, it is important that you read the following information and ask as many questions as necessary to be sure you understand what your child will be asked to do.

Investigators:
Dr. Diane Poulin-Dubois is the principal investigator. She is a faculty member in Psychology at Concordia University and is the director of the Cognitive and Language Development Laboratory which is part of the Center for Research in Human Development.

Purpose of the Study:
We are interested in the relation between early language and school readiness from the second year of life through pre-school. This study will take place across the next 4 years involving 7 visits in all. Before each visit, we will contact you by email or phone to schedule, provide you with detailed information about what we will be doing during that visit, and will answer any questions. This study is taking place in Montreal and also in San Diego, USA, and Geneva, Switzerland. We are studying children who are learning English, Spanish, and French. A total of 250 parents and their children are being invited to participate.

Description of the Study:
If you agree to participate, you and your child will visit the Cognitive and Language Development Laboratory at Concordia University (Montreal, QC) at the following ages: 16, 22, 28, 32, 36, 48, and 54 months. By observing how your child's language skills develop over this time frame we will learn about some of the skills that may be important in preparing children for school. Each visit will be scheduled at a convenient time for you. A researcher will meet you when you park and walk you to the lab. During each 20-60 min visit your child will be asked to point to pictures that represent words, shapes, numbers, and colors. On some visits, your child will see pictures on a computer screen and on others, s/he will see pictures in a book. We will also observe your child's responses to opportunities to play with toys and books. Your child will do some activities to assess some developmental changes and we will ask you to complete surveys of your child's language. We will videotape you and your child (see video consent letter) in these visits. Finally, we will collect information about your baby's development and recent life events, and ask you to provide information about yourself and your family.

These visits will take place at the:
Cognitive and Language Development Laboratory
7141 Sherbrooke West, Psychology building (PY-276)
Montreal, QC, H4B 1R6

What is Experimental in this Study:
We will assess 1.) your child's early language as measured by their responses to prompts on a touch-sensitive computer screen and your reports, 2.) parent-child play and book reading, 3.) your child's ability to tell a story, repeat sequences of sounds and numbers, pay attention, and 4.) school readiness. All of the measures that we will use are experimental and are not diagnostic. They just give us a general idea of how language and thought are changing over time. It is currently not known how well these assessments predict school-readiness however, if we can predict school-readiness from early measures of language and attention, this may be useful in identifying children who require services prior to school entry.

Risks or Discomforts:
The risks involved with this experiment are minimal. However, your child may become fussy or uncomfortable because this is a new situation with unfamiliar people. To decrease the chance that your child might become upset, we provide a warm up period lasting about 10 minutes. This involves letting your child become comfortable in the setting by playing with some toys. If your child becomes upset, we will ask you to comfort him/her, and the procedure will be stopped.

Benefits of the Study:
Your involvement in this study will provide you with an opportunity to observe your child's developing language skills over time in a structured setting. In addition, we will share the results of your child's language and school-readiness assessments with you. However this information is not diagnostic. Children in this age range vary considerably in their skills. We will also provide you with referral information on local agencies which provide speech/language services should you have any concerns about your child's development. Your participation will provide important information on the course of communicative development from the second year of life through the preschool period. This information may contribute to the development of procedures for assessing and promoting school readiness. In past studies, parents have found their involvement in research enjoyable and informative. However, we cannot guarantee that you or your child will receive any direct benefits from this study.

Confidentiality:
The confidentiality of all the records identifying you and your child will be maintained to the extent allowed by law. No information regarding any participant's performance will be disclosed to anyone in a way that identifies any individual participant. Each participant will be given an identification number and all the data will be recorded under that number. Videotapes of the participants will be used only for research and educational purposes and will be kept indefinitely in a secure location accessible only to the laboratory staff.

Costs and/or Compensation for Participation:
You will receive a lump sum of $25 at the end of each visit and your child will receive a Certificate of Merit for Contribution to Science and a small gift, even if he or she doesn't complete all of the tasks during the session. In addition, parents will receive an annual newsletter notifying them of the progress of our research.

Voluntary Nature of Participation:
Participation in this study is voluntary. Your decision regarding participation will not influence your or your infant's future relations with Concordia University. If you decide to let your child participate, you are free to withdraw your consent and to discontinue participation at any time without penalty or loss of benefits to which you or your child are otherwise entitled.

Questions about the Study:
If you have any questions at the moment please ask. If you have questions later about the research, you may contact: Dr. Diane Poulin-Dubois at 514-848-2424 ext. 2219 or Katherine Gittins at 514-848-2424 ext. 2279.
If you have any questions about your rights as a participant in this study, you may contact the Institutional Review Board (telephone: 514-848-2424, ext. 7481; email: ethics@alcor.concordia.ca).

Consent:
The Institutional Review Board at Concordia University has approved this consent form as signified by the Board's stamp. The consent form must be reviewed annually and expires on the date indicated on the stamp.

Your signature below indicates that you have read the information above and have had a chance to ask any questions you have about the study. You agree to let your child be in the study and have been told that you can change your mind at any time and withdraw your consent to participate at any time. You have been given a copy of this consent form. You have been told that by signing this consent form you are not giving up any of your legal rights.

Name of child (please print)

Name of Parent/Guardian (please print)

Signature of Parent/Guardian of child **Date**

Signature of Investigator **Date**

General Consent Form to Participate in Research

Concordia University
Researcher: Dr. Diane Poulin-Dubois
Protocol: The Path to Literacy

You are being asked to allow your child to participate in a research study. Before you give your consent to let your child be a volunteer, it is important that you read the following information and ask as many questions as necessary to be sure you understand what your child will be asked to do.

Investigators:
Dr. Diane Poulin-Dubois is the principal investigator. She is a faculty member in Psychology at Concordia University and is the director of the Cognitive and Language Development Laboratory which is part of the Center for Research in Human Development.

Purpose of the Study:
We are interested in the relation between early language and school readiness from the second year of life through pre-school. This study will take place across the next 4 years involving 7 visits in all. Before each visit, we will contact you by email or phone to schedule, provide you with detailed information about what we will be doing during that visit, and will answer any questions. This study is taking place in Montreal and also in San Diego, USA, and Geneva, Switzerland. We are studying children who are learning English, Spanish, and French. A total of 250 parents and their children are being invited to participate.

Description of the Study:
If you agree to participate, you and your child will visit the Cognitive and Language Development Laboratory at Concordia University (Montreal, QC) at the following ages: 16, 22, 28, 32, 36, 48, and 54 months. By observing how your child's language skills develop over this time frame we will learn about some of the skills that may be important in preparing children for school. Each visit will be scheduled at a convenient time for you. A researcher will meet you when you park and walk you to the lab. During each 60 min visit your child will be asked to point to pictures that represent words, shapes, numbers, and colors. On some visits, your child will see pictures on a computer screen and on others, s/he will see pictures in a book. We will also observe your child's responses to opportunities to play with toys and books. Other tasks will measure cognitive flexibility. For example, your child will be taught to put small balls in a small bucket and big balls in a larger bucket. Then, the rule will be changed and your child will be asked to put the small balls in the big bucket and the big balls in the small one. Your child will do some activities to assess some developmental changes and we will ask you to complete surveys of your child's language. We will videotape you and your child (see video consent letter) in these visits. Finally, we will collect information about your baby's development and recent life events.

These visits will take place at the:
Cognitive and Language Development Laboratory
7141 Sherbrooke West, Psychology building (PY-276)
Montreal, QC, H4B 1R6

What is Experimental in this Study:
We will assess 1) your child's early language as measured by their responses to prompts on a touch-sensitive computer screen and your reports, 2) parent-child play and book reading, 3) your child's ability to tell a story, repeat sequences of sounds and numbers, pay attention, and 4) school readiness. All of the measures that we will use are experimental and are not diagnostic. They just give us a general idea of how language and thought are changing over time. It is currently not known how well these assessments predict school-readiness however, if we can predict school-readiness from early measures of language and attention, this may be useful in identifying children who require services prior to school entry.

Risks or Discomforts:
The risks involved with this experiment are minimal. However, your child may become fussy or uncomfortable because this is a new situation with unfamiliar people. To decrease the chance that your child might become upset, we provide a warm up period lasting about 10 minutes. This involves letting your child become comfortable in the setting by playing with some toys. If your child becomes upset, we will ask you to comfort him/her, and the procedure will be stopped.

Benefits of the Study:
Your involvement in this study will provide you with an opportunity to observe your child's developing language skills over time in a structured setting. In addition, we will share the results of your child's language and school-readiness assessments with you. However this information is not diagnostic. Children in this age range vary considerably in their skills. We will also provide you with referral information on local agencies which provide speech/language services should you have any concerns about your child's development. Your participation will provide important information on the course of communicative development from the second year of life through the preschool period. This information may contribute to the development of procedures for assessing and promoting school readiness. In past studies, parents have found their involvement in research enjoyable and informative. However, we cannot guarantee that you or your child will receive any direct benefits from this study.

Confidentiality:
The confidentiality of all the records identifying you and your child will be maintained to the extent allowed by law. No information regarding any participant's performance will be disclosed to anyone in a way that identifies any individual participant. Each participant will be given an identification number and all the data will be recorded under that number. Videotapes of the participants will be used only for research and educational purposes and will be kept indefinitely in a secure location accessible only to the laboratory staff.

Costs and/or Compensation for Participation:
You will receive a lump sum of $25 at the end of each visit and your child will receive a Certificate of Merit for Contribution to Science and a small gift, even if he or she doesn't complete all of the tasks during the session. In addition, parents will receive an annual newsletter notifying them of the progress of our research.

Voluntary Nature of Participation:
Participation in this study is voluntary. Your decision regarding participation will not influence your or your infant's future relations with Concordia University. If you decide to let your child participate, you are free to withdraw your consent and to discontinue participation at any time without penalty or loss of benefits to which you or your child are otherwise entitled.

Questions about the Study:
If you have any questions at the moment please ask. If you have questions later about the research, you may contact: Dr. Diane Poulin-Dubois at 514-848-2424 ext. 2219 or Monyka Rodrigues at 514-848-2424 ext. 2279.
If you have any questions about your rights as a participant in this study, you may contact the Institutional Review Board (telephone: 514-848-2424, ext. 7481; email: ethics@alcor.concordia.ca).

Consent:
The Institutional Review Board at Concordia University has approved this consent form as signified by the Board's stamp. The consent form must be reviewed annually and expires on the date indicated on the stamp.

Your signature below indicates that you have read the information above and have had a chance to ask any questions you have about the study. You agree to let your child be in the study and have been told that you can change your mind at any time and withdraw your consent to participate at any time. You have been given a copy of this consent form. You have been told that by signing this consent form you are not giving up any of your legal rights.

Before the testing of my child at the age of 28-30 months, I would be interested in participating in other studies on language or cognitive development conducted by our research team or by Dr. Byers-Heinlein: **Yes No**

If yes, please select when we may contact you:

☐	In 1 Month
☐	In 2 Months
☐	In 3 Months

Name of child (please print)

Name of Parent/Guardian (please print)

Signature of Parent/Guardian of child **Date**

Signature of Investigator **Date**

General Consent Form to Participate in Research

Concordia University
Researcher: Dr. Diane Poulin-Dubois
Protocol: The Path to Literacy

You are being asked to allow your child to participate in a research study. Before you give your consent to let your child be a volunteer, it is important that you read the following information and ask as many questions as necessary to be sure you understand what your child will be asked to do.

Investigators:
Dr. Diane Poulin-Dubois is the principal investigator. She is a faculty member in Psychology at Concordia University and is the director of the Cognitive and Language Development Laboratory which is part of the Center for Research in Human Development.

Purpose of the Study:
We are interested in the relation between early language and school readiness from the second year of life through pre-school. This study will take place across the next 3 years involving 7 visits in all. Before each visit, we will contact you by email or phone to schedule, provide you with detailed information about what we will be doing during that visit, and will answer any questions. This study is taking place in Montreal and also in San Diego, USA, and Geneva, Switzerland. We are studying children who are learning English, Spanish, and French. A total of 250 parents and their children are being invited to participate.

Description of the Study:
If you agree to participate, you and your child will visit the Cognitive and Language Development Laboratory at Concordia University (Montreal, QC) at the following ages: 16, 22, 28, 36, 48, and 54 months. By observing how your child's language skills develop over this time frame we will learn about some of the skills that may be important in preparing children for school. Each visit will be scheduled at a convenient time for you. A researcher will meet you when you park and walk you to the lab. During each 60 min visit we will observe your child's responses to opportunities to play with toys and books. Other tasks will measure cognitive flexibility. For example, your child will be taught to put small cubes in a small bucket and big cubes in a larger bucket. Then, the rule will be changed and your child will be asked to put the small cubes in the big bucket and the big cubes in the small one. Your child will do some activities to assess some developmental changes and we will ask you to complete surveys of your child's language. We will record you and your child (see video consent letter) in these visits. Finally, we will collect information about your baby's development and recent life events.

These visits will take place at the:
Cognitive and Language Development Laboratory
7141 Sherbrooke West, Psychology building (PY-276)
Montreal, QC, H4B 1R6

What is Experimental in this Study:
We will assess 1) your child's early language as measured by their responses to prompts on a touch-sensitive computer screen and your reports, 2) parent-child play and book reading, 3) your child's ability to tell a story, repeat sequences of sounds and numbers, pay attention, and 4) school readiness. All of the measures that we will use are experimental and are not diagnostic. They just give us a general idea of how language and thought are changing over time. It is currently not known how well these assessments predict school-readiness however, if we can predict school-readiness from early measures of language and attention, this may be useful in identifying children who require services prior to school entry.

Risks or Discomforts:
The risks involved with this experiment are minimal. However, your child may become fussy or uncomfortable because this is a new situation with unfamiliar people. To decrease the chance that your child might become upset, we provide a warm up period lasting about 10 minutes. This involves letting your child become comfortable in the setting by playing with some toys. If your child becomes upset, we will ask you to comfort him/her, and the procedure will be stopped.

Benefits of the Study:
Your involvement in this study will provide you with an opportunity to observe your child's developing language skills over time in a structured setting. In addition, we will share the results of your child's language and school-readiness assessments with you. However this information is not diagnostic. Children in this age range vary considerably in their skills. We will also provide you with referral information on local agencies which provide speech/language services should you have any concerns about your child's development. Your participation will provide important information on the course of communicative development from the second year of life through the preschool period. This information may contribute to the development of procedures for assessing and promoting school readiness. In past studies, parents have found their involvement in research enjoyable and informative. However, we cannot guarantee that you or your child will receive any direct benefits from this study.

Confidentiality:
The confidentiality of all the records identifying you and your child will be maintained to the extent allowed by law. No information regarding any participant's performance will be disclosed to anyone in a way that identifies any individual participant. Each participant will be given an identification number and all the data will be recorded under that number. Videotapes of the participants will be used only for research and educational purposes and will be kept indefinitely in a secure location accessible only to the laboratory staff.

Costs and/or Compensation for Participation:
You will receive a lump sum of $25 at the end of each visit and your child will receive a Certificate of Merit for Contribution to Science and a small gift, even if he or she doesn't complete all of the tasks during the session. In addition, parents will receive an annual newsletter notifying them of the progress of our research.

Voluntary Nature of Participation:
Participation in this study is voluntary. Your decision regarding participation will not influence your or your infant's future relations with Concordia University. If you decide to let your child participate, you are free to withdraw your consent and to discontinue participation at any time without penalty or loss of benefits to which you or your child are otherwise entitled.

Questions about the Study:
If you have any questions at the moment please ask. If you have questions later about the research, you may contact: Dr. Diane Poulin-Dubois at 514-848-2424 ext. 2219 or Monyka Rodrigues at 514-848-2424 ext. 2279.
If you have any questions about your rights as a participant in this study, you may contact the Research Ethics Board (telephone: 514-848-2424, ext. 7481; email: ethics@alcor.concordia.ca).

Consent:
The Human Research Ethics Board at Concordia University has approved this consent form as signified by the certificate number UH2003-058-6. The consent form must be reviewed annually and expires on the date indicated on the certificate.

Your signature below indicates that you have read the information above and have had a chance to ask any questions you have about the study. You agree to let your child be in the study and have been told that you can change your mind at any time and withdraw your consent to participate at any time. You have been given a copy of this consent form. You have been told that by signing this consent form you are not giving up any of your legal rights.

Name of child (please print)

Name of Parent/Guardian (please print)

Signature of Parent/Guardian of child **Date**

Signature of Investigator **Date**

Concordia University Video Recording/Photo Release Consent Form

The Path to Literacy

Video recordings will be made of you/your child while participating in aspects of this research project. The informed consent document describes how the video or photo images will be used for this specific study as well as who will have access to the images and where the records will be maintained. The researcher would like your permission to use you/your child's video/photo image for purposes outside of the study. Please use this form to indicate whether you are willing to allow the use of your image/your child's image in any case. You and/or your child's name will not be associated to the images used and will only be used for consent purposes. You may request to stop the video taping or erase any portion of the tape at any time.

	Yes	No
1.The videotapes/photographs can be used for scientific publications and/or presentations.	☐	☐
2.The videotapes/photographs can be shown in classrooms to students.	☐	☐
3.The photos can be used in recruitment material	☐	☐
4.The videotapes/photographs can be stored in the lab until further use and/or publication.	☐	☐
5. The videotapes/photographs can be shown to collaborators on the project: Dr. Margaret Friend (San Diego State University), Dr. Gedeon Deak (University of California, San Diego) and, Dr. Pascal Zesiger (Université de Genève).	☐	☐

Your signature indicates that you have read the information and made a decision about how your video image / photograph may be used.

Signature: _____

Date: _____

Project: The Path to Literacy

Parental Consent Form

This is to state that I agree to allow my child to participate in a research project being conducted by Dr. Diane Poulin-Dubois, in collaboration with Jessica Reider and Cristina Crivello of Concordia University.

A. PURPOSE

I have been informed that the purpose of the research is to examine bilingual infants' early cognitive and language development.

B. PROCEDURES

The present investigation involves two visits to the Cognitive and Language Development Laboratory. First, you will be asked to complete a brief questionnaire on some demographic information (e.g., siblings, education), and a questionnaire on your child's vocabulary. Next, your child will participate in a few activities with the experimenter. Language comprehension will be assessed with a computerized task that requires your child to touch an image on a computer screen that corresponds to a word. Subsequent tasks will measure selective attention and cognitive flexibility. For example, your child will be asked to put small blocks in a small bucket and big blocks in a larger bucket. In another game, a snack will be placed under a transparent cup and your child will be asked to wait until the experimenter rings a bell before getting it. During all tasks, your child will either be sitting on your lap or sitting in a child seat while you are seated directly behind him/her.

We will film your child's responses and all videos will be treated in the strictest of confidentiality. That means the researcher will not reveal your child's identity in any written or oral reports about the study. You and your child will be assigned a coded number, and that code will be used on all materials collected in this study. All materials and data will be stored in secure facilities in the Department of Psychology at Concordia University. Only members of the research team will have access to these facilities. Questionnaires and electronic data files will be identified by coded identification numbers, unique to each family. Information collected on paper (questionnaires) or videos (observed behaviors) will be entered into computer databases. Raw data will be kept for a minimum of 5 years. When it is time for disposal, papers will be shredded, hard-drives will be purged, and computer disks will be magnetically erased. As well, because we are only interested in comparing children's understanding as a function of age, no individual scores will be provided following participation. Your participation will involve 2 visits, approximately 30-45 minutes each.

C. RISKS AND BENEFITS

Your child will be given a certificate of merit at the end of the session as a thank-you for his/her participation. Also, you will be offered 40$ total for your participation for both visits.

There is one condition that may result in the researchers being required to break the confidentiality of your child's participation. There are no procedures in this investigation that inquire about child maltreatment directly. However, by the laws of Québec and Canada, if the researchers discover information that indicates the possibility of child maltreatment, or that your child is at risk for imminent harm, they are required to disclose this information to the appropriate agencies. If this concern emerges, the lead researcher, Dr. Diane Poulin-Dubois, will discuss the reasons for this concern with you and will advise you of what steps will have to be taken.

D. CONDITIONS OF PARTICIPATION

- I understand that I am free to withdraw my consent and discontinue my participation at any time without negative consequences, and that the experimenter will gladly answer any questions that might arise during the course of the research. I am entitled to keep the total amount of $40 if I choose to withdraw my participation in the study.

- I understand that my participation in this study is confidential (i.e. the researchers will know, but will not disclose my identity).

- I understand that the data from this study may be published, though no individual scores will be reported.

I would be interested in participating in other studies conducted through the Centre for Research in Human Development with my child in the future (YES / NO): _____

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOUNTARILY AGREE TO HAVE MY CHILD PARTICIPATE IN THIS STUDY.

MY CHILD'S NAME (please print) _____

MY NAME (please print) _____

SIGNATURE _____ DATE _____

WITNESSED BY _____ DATE _____

If at any time you have questions about your rights as a research participant, you are free to contact the Research Ethics and Compliance Officer of Concordia University, at (514) 848-2424 ext: 7481 or by email at ethics@alcor.concordia.ca

_____
Diane Poulin-Dubois, Ph.D.
Professor
Department of Psychology
514-848-2424 ext. 2219
diane.poulindubois@concordia.ca

_____
Jessica Reider
B.A. Candidate
Department of Psychology
514-848-2424 ext. 2279

Appendix C: Demographics and Language Questionnaires

Concordia University demographics questionnaire (Waves 1-3 & CCT TE study)

Language exposure questionnaire (Waves 1-3 & CCT TE Study)

Concordia Cognitive and Language Development Laboratory

Participant Information

Child's Name: _____
First Last

Child's Date of Birth: _____ Child's Gender: ☐ M ☐ F
MM / DD / YY

Basic Family Information

Parent A's Full Name: _____ ☐ **M** ☐ **F**
First **Last**

Parent B's Full Name: _____ ☐ **M** ☐ **F**
First **Last**

Address (including **postal code**):

_____

_____

Phone numbers	**Where?** (e.g. home, Mom work, Dad cell)
1.	
2.	
3.	
4.	
5.	

E-mail: _____

Does your child have any siblings?

Name of Sibling	**Date of Birth**	**Gender**	**Can we contact you for future studies for this child?**
		M F	☐ **Yes** ☐ **No**
		M F	☐ **Yes** ☐ **No**
		M F	☐ **Yes** ☐ **No**

Does the participant live at home with his/her parent(s)? Yes No

If not, what are the participant's living arrangements?

1. Group Home
2. Independently
3. With other family members
4. Other (please explain)_____

Who else lives in the home with the participant?

Relationship to the participant	Age	Gender	Diagnosis, if any

What is the participant's diagnosis, if any?

_____

Does the participant carry any secondary diagnosis, and if so, what is it?

_____

At what age was the participant diagnosed? _____

Who diagnosed the participant?_____
Has the diagnosis ever been called into question? Yes No
If yes, please explain._____
_____

At what age did the participant begin treatment? _____
What type of treatment was this? _____

What is the main type of treatment that the participant is currently receiving?

_____

For how many hours per week?
At home?_____ At school?_____

What is the participant's school day like?

1. S/he is mainstreamed without any extra help
2. S/he is mainstreamed and shares an aide with one or more other children
3. S/he is mainstreamed and has his/her own educational aide

4. S/he is mainstreamed for some classes (e.g. music, physed), but is in a special needs classroom for most academic subjects
5. S/he is in a special needs classroom all day
6. S/he is in a classroom for children with emotional/behavioural difficulties
7. Other (please explain)_____

_____

Please list any other types of treatment that the participant is receiving with approximately how many hours per week s/he is receiving them.

_____

_____

_____

Is there any history of autism spectrum disorder in your immediate family? Yes No
If yes, please explain_____

Is there any history of autism spectrum disorder in your extended family? Yes No
If yes, please explain_____

Is there any history of language or reading problems in your immediate/extended family?
Yes No
If yes, please explain_____

Is there any history of psychiatric disorders in your immediate/extended family? Yes No
If yes, please explain_____

Did the participant experience seizures, ear infections, head trauma or serious illness as a young child? Yes No
If yes, please explain_____

Languages Spoken in the Home, School, or Childcare Setting

What percent of the time does your child hear **English**? _____ **%**
What percent of the time does your child hear **French?**_____ **%**
What percent of the time does your child hear **another language**? _____ **%**

In what language has your child been educated? _____

Has your child ever been educated in another language? **Yes_____ No_____**

If so, what language were they educated in? _____

From _____ years-old until _____ years-old

Health History

What was your child's birth weight? **__ __ lbs __ __ oz** OR **__ __ __ __ grams**
How many weeks was your pregnancy? _____**weeks**

Were there any **complications** during the pregnancy? ☐ **Yes** ☐ **No**

If yes please detail _____

Has your child had any major **medical problems**?
If yes please detail_____

Does your child have any **hearing or vision problems**?
If yes please detail_____

Does your child **currently** have an ear infection? ☐ **Yes** ☐ **No**

Has your child had any ear infections **in the past**? ☐ **Yes** ☐ **No**
If yes at which ages_____

Does your child have a **cold** today? ☐ **Yes** ☐ **No**

If yes, does he/she have pressure/pain in ears (if known)? ☐ **Yes** ☐ **No**
Is there any other relevant information we should know (health or language-related)?

Has another university contacted you to participate in one of their studies? ☐ **Yes** ☐ **No**
If yes, which university? _____

Family and Child Background Information (optional)

If the participant is living at home, what is the marital status of the parent(s) s/he is living with?

- ☐ Married
- ☐ Separated
- ☐ Remarried
- ☐ Single
- ☐ Divorced
- ☐ Common-Law
- ☐ Widowed
- ☐ Other

In which of the following ranges does your annual household income fall?

- ☐ $25,000 or less
- ☐ $25,001-$35,000
- ☐ $35,001-$45,000
- ☐ $45,001-$55,000
- ☐ $55,001-$65,000
- ☐ $65,001-$75,000
- ☐ $75,001-$85,000
- ☐ $85,001-$95,000
- ☐ $95,001 or more

Parent A's Current Level of Education
Check any/all that apply:

- ☐ Primary School
- ☐ Some High School
- ☐ High School
- ☐ Some College/University
- ☐ College Certificate/Diploma
- ☐ Trade School Diploma
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ Doctoral Degree
- ☐ Professional Degree
- ☐ Not Applicable/Unknown
- ☐ Other (please specify):

Parent B's Current Level of Education
Check any/all that apply:

- ☐ Primary School
- ☐ Some High School
- ☐ High School
- ☐ Some College/University
- ☐ College Certificate/Diploma
- ☐ Trade School Diploma
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ Doctoral Degree
- ☐ Professional Degree
- ☐ Not Applicable/Unknown
- ☐ Other (please specify):

Parent A's Occupational Status (optional)
Check any/all that apply:

- ☐ Employed Full-Time
- ☐ Employed Part-Time
- ☐ Stay-at-Home-Parent
- ☐ Student
- ☐ Unemployed
- ☐ Not Applicable/Unknown
- ☐ On Temporary Leave (e.g., maternity, paternity, sick, etc.; **please also check status when not on leave**)
- ☐ Other (please specify):

_____
_____
_____

Parent B's Occupational Status (optional)
Check any/all that apply:

- ☐ Employed Full-Time
- ☐ Employed Part-Time
- ☐ Stay-at-Home-Parent
- ☐ Student
- ☐ Unemployed
- ☐ Not Applicable/Unknown
- ☐ On Temporary Leave (e.g., maternity, paternity, sick, etc.; **please also check status when not on leave**)
- ☐ Other (please specify):

_____
_____
_____

What are your child's ethnic origins?
Check any/all that apply:

- ☐ Aboriginal
- ☐ African
- ☐ Arab
- ☐ West Asian
- ☐ South Asian
- ☐ East and Southeast Asian
- ☐ Caribbean
- ☐ European
- ☐ Latin/Central/South American
- ☐ Pacific Islands
- ☐ Canadian

☐ Other (please specify):

_____

Path to Literacy

Bilingual Language Exposure Questionnaire

Date of Study: _____ E1 and E2 initials: _____

Study ID: _____ Study Name: Path to Literacy

Child's Date of Birth: _____ Parent/Caregiver: _____

Language Environment

Global Parent Estimate: French ☐ **English** ☐ **Other** ☐

Who spends time with the baby and what languages do they speak (Exposure to monolingual or to bilingual adults)?

Person	Language 1 %		Language 2 %		Notes

_____

Waking Hours (nap time hours)

_____

Mother's Work Hours

_____

Father's Work Hours

_____

Daycare Hours

_____

Other Hours

Appendix D: Coding Sheets & CCT Checklist

CCT Child Checklist: Form A English coding sheet (Waves 1 & 2)
CCT Child Checklist: Form B English coding sheet (Waves 1 & 2)
CCT Child Checklist: Form A French coding sheet (Waves 1 & 2)
CCT Child Checklist: Form B French coding sheet (Waves 1 & 2)
CCT Child Checklist: TE coding sheet (CCT TE Study)

Form A Child Checklist

Nouns: **Where is the _____?**

Verbs: **Who is _____?**

Adjectives: **Which one is ____?"**

Word	Recognizes?				Difficulty
Shoe	**Y**	**N**	**M**	**A**	E
Car	**Y**	**N**	**M**	**A**	E
Dog	**Y**	**N**	**M**	**A**	E
Running	**Y**	**N**	**M**	**A**	M
Mouth	**Y**	**N**	**M**	**A**	E
Sheep	**Y**	**N**	**M**	**A**	D
Green	**Y**	**N**	**M**	**A**	D
Hugging	**Y**	**N**	**M**	**A**	E
Pulling	**Y**	**N**	**M**	**A**	D
Telephone	**Y**	**N**	**M**	**A**	E
Drawing	**Y**	**N**	**M**	**A**	D
Bus	**Y**	**N**	**M**	**A**	D
Foot	**Y**	**N**	**M**	**A**	E
Happy	**Y**	**N**	**M**	**A**	D
Button	**Y**	**N**	**M**	**A**	M
Banana	**Y**	**N**	**M**	**A**	E
Old	**Y**	**N**	**M**	**A**	D
Toothbrush	**Y**	**N**	**M**	**A**	E
Dancing	**Y**	**N**	**M**	**A**	E
Jumping	**Y**	**N**	**M**	**A**	M
Horse	**Y**	**N**	**M**	**A**	M
Cookies	**Y**	**N**	**M**	**A**	E
Table	**Y**	**N**	**M**	**A**	M
Big	**Y**	**N**	**M**	**A**	D
Eating	**Y**	**N**	**M**	**A**	E
Scissors	**Y**	**N**	**M**	**A**	D
Blue	**Y**	**N**	**M**	**A**	D
Airplane	**Y**	**N**	**M**	**A**	M
Full	**Y**	**N**	**M**	**A**	D
Train	**Y**	**N**	**M**	**A**	M
Penguin	**Y**	**N**	**M**	**A**	D
Apple	**Y**	**N**	**M**	**A**	E
Smiling	**Y**	**N**	**M**	**A**	M
Playing	**Y**	**N**	**M**	**A**	M
Ball	**Y**	**N**	**M**	**A**	E
Reading	**Y**	**N**	**M**	**A**	M
Bubbles	**Y**	**N**	**M**	**A**	M
Butterfly	**Y**	**N**	**M**	**A**	D
Touching	**Y**	**N**	**M**	**A**	M
Clean	**Y**	**N**	**M**	**A**	M
Duck	**Y**	**N**	**M**	**A**	E
Pig	**Y**	**N**	**M**	**A**	M
Boy	**Y**	**N**	**M**	**A**	D

Form B Child Checklist

Nouns: **Where is the _____?**

Verbs: **Who is _____?**

Adjectives: **Which one is ____?"**

Word	Recognizes?				Difficulty
Diaper	**Y**	**N**	**M**	**A**	E
Book	**Y**	**N**	**M**	**A**	E
Bird	**Y**	**N**	**M**	**A**	E
Sliding	**Y**	**N**	**M**	**A**	M
Eye	**Y**	**N**	**M**	**A**	E
Lion	**Y**	**N**	**M**	**A**	D
Orange	**Y**	**N**	**M**	**A**	D
Kissing	**Y**	**N**	**M**	**A**	E
Swimming	**Y**	**N**	**M**	**A**	D
Keys	**Y**	**N**	**M**	**A**	E
Kicking	**Y**	**N**	**M**	**A**	D
Fire Truck	**Y**	**N**	**M**	**A**	D
Nose	**Y**	**N**	**M**	**A**	E
Sad	**Y**	**N**	**M**	**A**	D
Hat	**Y**	**N**	**M**	**A**	M
Juice	**Y**	**N**	**M**	**A**	E
New	**Y**	**N**	**M**	**A**	D
Spoon	**Y**	**N**	**M**	**A**	E
Drinking	**Y**	**N**	**M**	**A**	E
Swinging	**Y**	**N**	**M**	**A**	M
Cow	**Y**	**N**	**M**	**A**	M
Milk	**Y**	**N**	**M**	**A**	E
Chair	**Y**	**N**	**M**	**A**	M
Little	**Y**	**N**	**M**	**A**	D
Throwing	**Y**	**N**	**M**	**A**	E
Money	**Y**	**N**	**M**	**A**	D
Red	**Y**	**N**	**M**	**A**	D
Truck	**Y**	**N**	**M**	**A**	M
Empty	**Y**	**N**	**M**	**A**	D
Bicycle	**Y**	**N**	**M**	**A**	M
Giraffe	**Y**	**N**	**M**	**A**	D
Cheese	**Y**	**N**	**M**	**A**	E
Crying	**Y**	**N**	**M**	**A**	M
Sleeping	**Y**	**N**	**M**	**A**	M
Bottle	**Y**	**N**	**M**	**A**	E
Washing	**Y**	**N**	**M**	**A**	M
Doll	**Y**	**N**	**M**	**A**	M
Turtle	**Y**	**N**	**M**	**A**	D
Riding	**Y**	**N**	**M**	**A**	M
Dirty	**Y**	**N**	**M**	**A**	M
Cat	**Y**	**N**	**M**	**A**	E
Fish	**Y**	**N**	**M**	**A**	M
Girl	**Y**	**N**	**M**	**A**	D

Form A Child Checklist

Ou est le (chat)? Touche (chat).
Lequel est (bleu)? Touche (bleu).
Qui est en train de (danser)? Touche (danser).

Word	Recognizes?				Difficulty
Chat	Y	N	M	A	E
Jouer	Y	N	M	A	M
Livre	Y	N	M	A	E
Papillon	Y	N	M	A	D
Rouge	Y	N	M	A	D
Manger	Y	N	M	A	E
Faire manger	Y	N	M	A	D
Cuillère	Y	N	M	A	E
Dessiner	Y	N	M	A	D
Toast	Y	N	M	A	E
Bas	Y	N	M	A	E
Sale	Y	N	M	A	M
Poisson	Y	N	M	A	M
Pain	Y	N	M	A	E
Cassé	Y	N	M	A	D
Chaise	Y	N	M	A	E
Laver	Y	N	M	A	E
Marcher	Y	N	M	A	M
Banane	Y	N	M	A	M
Pyjama	Y	N	M	A	E
Train	Y	N	M	A	M
Content	Y	N	M	A	D
Danser	Y	N	M	A	E
Giraffe	Y	N	M	A	D
Mouillé	Y	N	M	A	D
Manteau	Y	N	M	A	M
Petit	Y	N	M	A	D
Doigt	Y	N	M	A	M
Poney	Y	N	M	A	D
Nez	Y	N	M	A	E
Courir	Y	N	M	A	M
Pousser	Y	N	M	A	M
Crayon	Y	N	M	A	E
Tirer	Y	N	M	A	D
Bouteille	Y	N	M	A	M
Manteau	Y	N	M	A	D
Ouvrir	Y	N	M	A	M
Chemise	Y	N	M	A	D
Poussette	Y	N	M	A	E
Cheval	Y	N	M	A	M
Pomme	Y	N	M	A	M

Form B Child Checklist

Ou est le (chat)? Touche (chat).
Lequel est (bleu)? Touche (bleu).
Qui est en train de (danser)? Touche (danser).

Word	Recognizes?				Difficulty
Chien	Y	N	M	A	E
Souffler	Y	N	M	A	M
Ballon	Y	N	M	A	E
Lion	Y	N	M	A	D
Bleu	Y	N	M	A	D
Boire	Y	N	M	A	E
Nager	Y	N	M	A	D
Bavette	Y	N	M	A	E
Sauter	Y	N	M	A	D
Pizza	Y	N	M	A	D
Pantoufle	Y	N	M	A	E
Propre	Y	N	M	A	D
Canard	Y	N	M	A	M
Gâteau	Y	N	M	A	E
Froid	Y	N	M	A	D
Porte	Y	N	M	A	E
Donner	Y	N	M	A	E
Pleurer	Y	N	M	A	M
Soupe	Y	N	M	A	M
Lit	Y	N	M	A	E
Bicyclette	Y	N	M	A	M
Endormi	Y	N	M	A	D
Dormir	Y	N	M	A	E
Tortue	Y	N	M	A	D
Sec	Y	N	M	A	D
Chapeau	Y	N	M	A	M
Grand	Y	N	M	A	D
Bras	Y	N	M	A	M
Pingouin	Y	N	M	A	D
Pied	Y	N	M	A	E
Lire	Y	N	M	A	M
Essuyer	Y	N	M	A	M
Balai	Y	N	M	A	E
Écrire	Y	N	M	A	D
Fourchette	Y	N	M	A	M
Couverture	Y	N	M	A	D
Jeter	Y	N	M	A	M
Salopette	Y	N	M	A	D
Voiture	Y	N	M	A	E
Lapin	Y	N	M	A	M
Carotte	Y	N	M	A	M

CCT TE Study Child Checklist

English	French
Boy	garcon
foot	pied
smiling	sourire
cheese	fromage
truck	camion
blue	bleu
dancing	danser
full	plein
cat	chat
butterfly	papillon
drawing	dessiner
horse	cheval
bubbles	bulles
blowing	souffler
drinking	boire
telephone	telephone
bus	autobus
big	grand
happy	content
hat	chapeau
penguin	pingoin
mouth	bouche
crying	pleurer
juice	jus
airplane	avion
red	rouge
running	courir
dirty	sale
pig	cochon
bird	oiseau
playing	jouer
sheep	mouton
cookies	biscuit
touching	toucher
eating	manger
toothbrush	brosse a dents
table	table
little	petit
old	vieux
ball	balle