

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

JACQUELINE LEGACY

Concordia University

JESSICA REIDER

Concordia University

CRISTINA CRIVELLO

Concordia University

OLIVIA KUZYK

Concordia University

MARGARET FRIEND

San Diego State University

PASCAL ZESIGER

Université de Genève

AND

DIANE POULIN-DUBOIS

Concordia University

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ABSTRACT

In order to address gaps in the literature surrounding the acquisition of translation equivalents (TEs) in young bilinguals, two experiments were conducted. In Experiment 1, TEs were measured in the expressive vocabularies of thirty-four French–English bilinguals at 1;4, 1;10, and

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2;6 using the MacArthur Bates CDI. Children's acquisition of TEs occurred gradually, with more balanced ratios of exposure and vocabulary associated with larger proportions of TEs at each wave. Experiment 2 compared a direct measure of TE comprehension with parent report of the same set of words. Results showed that parents may over-report children's TE comprehension, as our sample of two-year-old French–English bilinguals ($n = 20$) comprehended fewer TEs on a direct measure of receptive vocabulary than parents reported on the vocabulary checklist. The present study provides an original contribution to the literature on bilingual vocabulary development by employing both a longitudinal design and a direct measure of TE comprehension.

INTRODUCTION

Decades of research suggests 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 (Nicoladis & Genesee, 1997; Oller, Eilers, Urbano & Cobo-Lewis, 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 (e.g., *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 thirty-four 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 *et al.*, 2012; Bosch & Ramon-Casas, 2014; David & Wei, 2008; De Anda, Arias-Trejo, Poulin-Dubois, Zesiger & Friend, 2016a; De Houwer, 2007; De Houwer, Bornstein & De Coster, 2006; Eilers, Pearson & Cobo-Lewis, 2006; Grüter, Hurtado, Marchman & Fernald, 2014; Hoff, 2013; Hurtado, Grüter, Marchman & Fernald, 2014; Pearson *et al.*, 1997; Place & Hoff, 2011; Poulin-Dubois *et al.*, 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; 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, Brosseau-Lapre & Petitto, 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), 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; Poulin-Dubois, D., Blaye, Coutya & Bialystok, 2011). 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: (i) 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 (ii) 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, fifty-seven 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 thirteen 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 thirty-four 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, 2016b). 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. These data were 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 *et al.*, 1993) and French Canadian (Trudeau *et al.*, 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. First, 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 have been included for the proportion of TEs with cognates and semi-cognates subtracted at each wave.

RESULTS AND 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 1 and Figures 1 & 2). 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 2). 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 2).

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,

TABLE 1. *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	0.37	0.76	–1.17–1.70	0.48	0.73	–0.94–1.87	0.72	0.72	–0.22–2.26
L1 exposure	0.64	0.09	0.51–0.78	0.64	0.10	0.50–0.79	0.64	0.08	0.50–0.78
L2 exposure	0.36	0.08	0.22–0.48	0.36	0.10	0.21–0.50	0.36	0.08	0.22–0.50
Relative exposure	0.57	0.37	0.08–1.27	0.62	0.45	0.0–1.32	0.58	0.36	0.0–1.27
Proportion TEs	0.49	0.16	0.0–0.74	0.53	0.16	0.26–0.89	0.61	0.22	0.22–0.97
Proportion TEs(minus cognates + semi cognates)	0.40	0.19	0.0–0.72	0.48	0.19	0.0–0.87	0.59	0.23	0.16–0.97

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TRANSLATION EQUIVALENTS IN YOUNG BILINGUALS

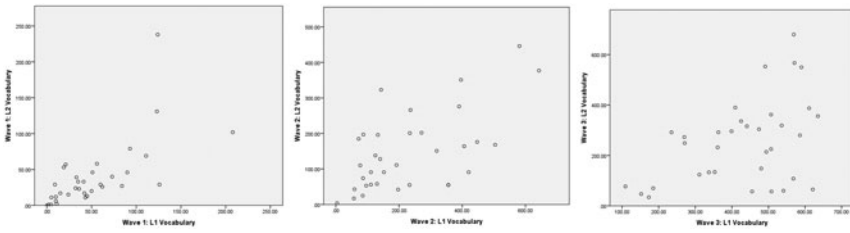


Fig. 1. Individual variability in L1 and L2 vocabulary size at Waves 1, 2 & 3.

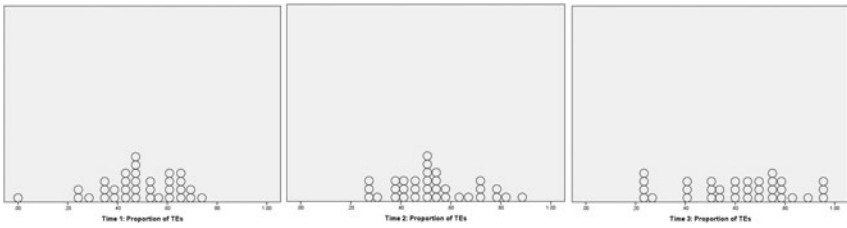


Fig. 2. Individual variability in the proportion of TEs across waves.

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 ($\Delta F(1,30) = 5.66, p = .024$; see Table 3). 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 ($\Delta F(1,31) = 24.10, p < .01$). 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

TABLE 2. *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	-	0.31 $p = .08$	0.36 $p = .04$	0.50* $p < .01$	0.09 $p = .63$	0.18 $p = .31$	-0.15 $p = .41$	0.04 $p = .82$	-0.35 $p = .05$
W2 relative vocabulary		-	0.29 $p = .09$	0.13 $p = .46$	0.52* $p < .01$	0.48* $p < .01$	-0.19 $p = .27$	-0.51* $p < .01$	-0.24 $p = .17$
W3 relative vocabulary			-	0.16 $p = .35$	0.31 $p = .07$	0.30 $p = .09$	-0.44* $p < .01$	-0.36 $p = .04$	-0.91* $p < .00$
W1 relative exposure				-	0.32 $p = .07$	0.30 $p = .08$	0.16 $p = .36$	-0.02 $p = .91$	-0.13 $p = .45$
W2 relative exposure					-	0.54* $p < .01$	-0.06 $p = .76$	-0.42* $p = .02$	-0.20 $p = .27$
W3 relative exposure						-	-0.24 $p = .17$	-0.30 $p = .08$	-0.43* $p = .01$
W1 TE							-	0.48* $p < .01$	0.49* $p < .01$
W2 TE								-	0.37 $p = .03$
W3 TE									-

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

TABLE 3. *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 (Waves 1–2 and Waves 2–3)*

	TE growth			
	Waves 1–2		Waves 2–3	
Predictors	Model 1	Model 2	Model 1	Model 2
Relative language exposure	–0.16	0.11	–0.32	–0.27*
Relative vocabulary	–	–0.48*	–	–0.63**
Total R ²	0.03	0.15	0.10	0.39

NOTES: * $p < .05$; ** $p < .01$.

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 ($r(32) = 0.38$, $p = .03$), this was not the case from 1;10 to 2;6 ($r(32) = -0.21$, $p = .31$). 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 preschool 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 twenty-two bilingual participants were tested. Of these twenty-two toddlers, two were excluded due to missing vocabulary measures. The

final sample consisted of twenty 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 *et al.*, 2016b).

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 forty 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, color, 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 forty 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.

RESULTS AND 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 4](#)). 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 5](#)).

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

TABLE 4. 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)	0.52	0.24	0.10–0.90
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)	0.68	0.27	0.05–1.0

TABLE 5. 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)	–	0.41 $p = .08$	–0.25 $p = .28$	0.94** $p < .01$	–0.28 $p = .23$
TEs (Checklist)		–	–0.52* $p = .02$	0.46* $p = .04$	–0.38 $p = .10$
Relative exposure			–	–0.31 $p = .19$	0.35 $p = .14$
CCT L2 vocabulary				–	–0.58* $p = .01$
CCT relative vocabulary					–

NOTES: * $p < .05$; ** $p < .01$.

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: (i) to investigate the development of TEs in a sample of young bilinguals across three developmental time-points; (ii) to examine whether relative language exposure contributes to early TE acquisition in these children; and (iii) 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 is the 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; Holowka *et al.*, 2002; Nicoladis & Secco, 2000; 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, 44% 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 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.*, used known and FAMILIAR word pairs, and Styles and Plunkett 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 (Styles & Plunkett, 2009, p. 907).

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 behavioral 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 behavior 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 (2007) 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, 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 AND 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. Last, 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 of 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.

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