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SHORT REPORT

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# Bilingual toddlers' comprehension of mixed sentences is asymmetrical across their two languages

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## Abstract

In bilingual language environments, infants and toddlers listen to two separate languages during the same key years that monolingual children listen to just one and bilinguals rarely learn each of their two languages at the same rate. Learning to understand language requires them to cope with challenges not found in monolingual input, notably the use of two languages within the same utterance (e.g., Do you like the *perro?* or *¿Te gusta el* doggy?). For bilinguals of all ages, switching between two languages can reduce the efficiency in real-time language processing. But language switching is a dynamic phenomenon in bilingual environments, presenting the young learner with many junctures where comprehension can be derailed or even supported. In this study, we tested 20 Spanish–English bilingual toddlers (18- to 30-months) who varied substantially in language dominance. Toddlers' eye movements were monitored as they looked at familiar objects and listened to single-language and mixed-language sentences in both of their languages. We found asymmetrical switch costs when toddlers were tested in their dominant versus non-dominant language, and critically, they benefited from hearing nouns produced in their dominant language, independent of switching. While bilingualism does present unique challenges, our results suggest a united picture of early monolingual and bilingual learning. Just like monolinguals, experience shapes bilingual toddlers' word knowledge, and with more robust representations, toddlers are better able to recognize words in diverse sentences.

KEYWORDS
bilingualism, language development, language processing, language switching, statistical learning, word representations

## 1 | INTRODUCTION

How do infants contend with everyday use of the language or languages in their environment? Research on early language learning has uncovered key features of language input, such as word frequency, in tandem with domain-general learning mechanisms, such as the ability to detect statistical patterns in the input (e.g., Benitez & Smith, 2012; Goodman, Dale, & Li, 2008; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Saffran, 2003). However, this research has largely focused on monolingual infants, who learn the words and regularities of one language. Bilingual infants face an environment that is inherently more complex, as they must learn words and regularities in two languages and integrate their learning across languages. In the current study, we ask how infants' processing of two languages can provide insight into how children's language knowledge develops through experience.

  

Bilingual language environments pose challenges not found in monolingual input. One unique challenge is the presence of mixed-language sentences, where two languages are used within a single utterance (e.g., *Do you like the perro?* or *¿Te gusta el doggy?*). Mixed-language sentences are reliably found in bilingual input, though they are significantly less common than single-language sentences. Recently, Bail, Morini, and Newman (2015) found that 3%–4% of utterances heard by bilingual children in a laboratory play session contained within-sentence switches, which is consistent with earlier case studies that have estimated the proportion to be between 3% and 20% (Bentahila & Davies, 1995; Goodz, 1989; Nicoladis & Secco, 2000; Pan, 1995; Tare & Gelman, 2011). While mixed-language sentences represent a relatively small proportion of bilingual children's total input, up to 90% of bilingual parents report mixing languages at least occasionally (Byers-Heinlein, 2013). Together, these estimates suggest that switches are common but nonetheless unexpected, and they potentially introduce a juncture in real-time language processing.

Bilinguals of all ages, including highly proficient adults, show reduced efficiency in processing language that contains switches (e.g., Byers-Heinlein, Morin-Lessard, & Lew-Williams, 2017; Costa & Santesteban, 2004; Potter, Fourakis, Morin-Lessard, Byers-Heinlein, & Lew-Williams, 2018). Language switching forces listeners to retrieve lexical items in the less active language (e.g., Green, 1998; Thomas & Allport, 2000), and this more effortful processing slows comprehension, particularly when switches are unpredictable (Blanco-Elorrieta & Pylkkänen, 2017; Chan, Chau, & Hoosain, 1983). In addition, not all switches are equally difficult for adult bilinguals to overcome. In production, adults tend to experience slow-downs when switching from their non-dominant to dominant language, which has been attributed to increased inhibition of the dominant language when it is not being spoken (e.g., Costa & Santesteban, 2004; Guo, Liu, Misra, & Kroll, 2011; Meuter & Allport, 1999). Studies of comprehension also reveal inconsistent and asymmetrical switch costs, although the direction of the asymmetry varies across tasks (e.g., Aparicio & Lavaur, 2014; Declerck & Grainger, 2017; Grainger & Beauvillain, 1987; Olson, 2016; Phillip & Huestegge, 2015). These heterogeneous findings highlight intersecting influences on adults' abilities to contend with mixed language, including task demands, the current linguistic context, and past experience with each language (Bobb & Wodniecka, 2013).

In the early stages of language development, bilinguals' knowledge and processing may be quite different across their two languages (e.g., Conboy & Mills, 2006). In fact, bilingual toddlers' vocabulary knowledge and processing efficiency across their two languages have been found to be only weakly correlated (e.g., Hoff, Quinn, & Giguere, 2017; Marchman, Fernald, & Hurtado, 2010). Instead, children's skills within a particular language are tied to the amount of input they receive in that language (e.g., Marchman, Martínez, Hurtado, Grüter, & Fernald, 2017; Place & Hoff, 2011). Because children tend to have more experience with one language (usually considered their dominant language), young bilinguals typically know more words and have more robust representations of words in this language (Legacy, Zesiger, Friend, & Poulin-Dubois, 2016; Singh, 2014). This imbalance further illustrates the important relation between (a) the frequency with which children hear sounds, syllables, and words, and (b) the richness of their word-object knowledge.

Given the asymmetry of bilingual children's knowledge of words across languages, we would expect differences in how they process challenging mixed-language sentences in their two languages. Byers-Heinlein et al. (2017) provided evidence that infants learning French and English experience processing costs mainly when listening to switches from their dominant to non-dominant language. However, this investigation only examined one language per child, which limits the ability to understand the interaction between language switching and other core aspects of early language learning, such as the robustness of word knowledge. Furthermore, testing only one language leaves open the possibility that some children are highly sensitive to switches, but others are not.

In this study, we extend previous research on bilingualism by providing a comprehensive, bidirectional examination of the effects of language mixing on real-time language processing. By testing bilingual toddlers on the same items across languages and conditions, toddlers served as their own controls, allowing us to disentangle effects of language mixing from language dominance (Potter et al., 2018). Moreover, while previous studies reported data from French–English bilinguals in Canada (Byers-Heinlein et al., 2017), we tested Spanish–English bilingual toddlers in the United States, and by doing so, we address the critical issue of generalizability in bilingualism research. Given broad, multi-level differences across bilingual environments (e.g., differences in language pairs, attitudes toward bilingualism, immigrant status, and governmental policy), and given the field's limited knowledge of how early learning proceeds in bilingual environments, it is essential to test whether findings are specific to one context.

**Research Highlights**

- Spanish–English bilingual toddlers were tested on their processing of single- and mixed-language sentences in each of their two languages.
- Processing was disrupted when toddlers heard a switch from their dominant to non-dominant language, but not vice versa.
- Like monolinguals, bilingual toddlers are better able to recognize nouns that are highly familiar, independent of language switching.
- With experience, toddlers integrate knowledge of familiar regularities and representations of individual words in order to process language efficiently.

Our main prediction was that Spanish–English bilingual toddlers would experience larger processing costs when listening to switches from their dominant to non-dominant language, because switches may interfere more with toddlers' understanding of nouns in their weaker (versus stronger) language. Additionally, we predicted that children – independent of switching – would show enhanced comprehension of nouns produced in the language with which they had more experience, consistent with findings from adults (e.g., Aparicio & Lavaur, 2014; Phillip & Huestegge, 2015). By investigating bilingual toddlers' comprehension of diverse sentences in two languages, this research points to a parsimonious explanation of early language processing that spans monolingual and bilingual environments.

## 2 | METHOD

Using the Looking-While-Listening procedure, we monitored Spanish–English bilingual toddlers' eye movements as they viewed pairs of familiar objects (e.g., dog, balloon) and heard a sentence labeling one object. On *Single-Language* trials, toddlers heard sentences all in one language (*Do you like the doggy?/¿Te gusta el perro?*). On *Switched-Language* trials, they heard sentences where the language of the sentence frame and the target noun differed (*Do you like the perro?/¿Te gusta el doggy?*). All toddlers participated in two consecutive sessions. During each session, they heard sentence frames in only English or only Spanish, and identical nouns were used on Single- and Switched-Language trials. By avoiding the potential effects of switching languages between trials, this design enabled us to focus on toddlers' comprehension of within-sentence switches. Participants were tested equally in both languages, allowing us to explore how children's processing of mixed-language sentences differed across their dominant and non-dominant languages.

### 2.1 | Participants

Participants were 20 18–30-month-old Spanish–English bilingual toddlers (14 girls, $M$ = 23.1 months, $SD$ = 3.5) living in a primarily English-speaking community in New Jersey, with no history of hearing problems or developmental delays. We selected this age range because this paradigm has been used successfully with toddlers between 18 and 30 months (e.g., Byers-Heinlein et al., 2017; Marchman et al., 2010) and because previous research on bilingual development does not yield empirical or theoretical reasons to expect differences between 18- and 30-month-olds. Based on interviews with parents using the Language Exposure Questionnaire (Bosch & Sebastián-Gallés, 2001), we derived an estimate of children's relative exposure to each language using an average of current and cumulative experiences. All participants had experience with both English and Spanish within their first 6 months of life, were exposed to each language at least 20% of the time, and had no significant exposure to a third language. Nine participants were reported to hear >50% Spanish in their daily lives and were classified as Spanish-dominant, and the remaining 11 participants were classified as English-dominant. Participants were exposed to their dominant language an average of 64% of the time ($SD$ = 2.1, range: 50%–79%). Data collection took place between November, 2016 and November, 2017, and 13 additional toddlers were tested but excluded for not meeting language criteria (1), language delay (1), fussiness (8), equipment error (1) or failing to provide data for at least two trials in all conditions (2). Informed consent was obtained from all participants and all toddlers received a small gift for participating.

### 2.2 | Stimuli and design

#### 2.2.1 | Auditory stimuli

Speech stimuli were produced by a female native bilingual speaker and consisted of infant-directed sentences in English and Spanish. Each sentence consisted of a sentence frame in one language (e.g., *Do you like the…/¿Te gusta el…*) and a target noun (e.g., *doggy, perro*). Nouns were chosen to be highly familiar, and according to vocabulary norms, all are reportedly produced by ≥75% of English-speaking 24-month-olds (Frank, Braginsky, Yurovsky, & Marchman, 2017) and >60% of Spanish-speaking 24-month-olds (Jackson-Maldonado et al., 2003). Yoked pairs of target and distracter items were matched on grammatical gender in Spanish so participants could not use the article *el* or *la* to predict the upcoming noun (Lew-Williams & Fernald, 2007). All sentences were produced naturally to preserve co-articulation between the article and the noun (Mahr, McMillan, Saffran, Ellis Weismer, & Edwards, 2015). Children encountered identical items and pairings across languages (*doggy-balloon/perro-globo, foot-kitty/pie-gato, mouth-milk/boca-leche, cookie-door/galleta-puerta)*. On *Single-Language* trials, the sentence frame and target noun were presented in the same language. On *Switched-Language* trials, there was a change in language at the noun (e.g., *Do you like the* perro?). The language switch occurred after the determiner to match typical patterns of bilingual language use (e.g., Jake, Myers-Scotton, & Gross, 2002; Poplack, 1987). Each item occurred equally often in each language and on Single- versus Switched-Language trials. Target words ranged from 303 to 971 ms in duration, and average duration did not differ by language (English: $M$ = 677 ms, Spanish: $M$ = 614 ms) or condition (Single-Language: $M$ = 608 ms, Switched-Language: $M$ = 683 ms).

#### 2.2.2 | Visual stimuli

Visual stimuli consisted of images of familiar objects presented on gray backgrounds. Pairs of images, matched for salience, appeared side-by-side on each trial. Side of presentation was counterbalanced, and all objects appeared equally often as the target and distracter.

### 2.3 | Procedure

All participants took part in two testing sessions. After the first session, children left the testing room to play for 5–10 min while parents filled out questionnaires. After this break, they returned to the testing room for the second session. During each session, participants sat on their parents' lap in a darkened room and viewed images on a 55" TV monitor while hearing speech over a loudspeaker[1]. Parents listened to masking music over headphones and were instructed not to interfere. Testing sessions consisted of 16 experimental trials (8 Single-Language, 8 Switched-Language), intermixed with filler videos every four trials to keep children engaged. On each trial, participants saw two familiar objects. Images appeared in silence for 2 s, and then participants heard a sentence labeling one of the objects, followed by approximately 2 s of silence for a total trial duration of 6.1 s. Trial orders were pseudo-randomized such that the same object pair never appeared on consecutive trials, and there were never more than three consecutive trials of the same type. Participants were randomly assigned to one of two counterbalanced orders for each language. All trials within a session used sentence frames in just one language. Participants were randomly assigned to participate in the English or Spanish session first. Twelve children were tested in their dominant language first, and eight were tested in their non-dominant language first.

In addition to being interviewed about their child's language exposure, parents filled out (a) the Spanish and English versions of the MacArthur-Bates Communicative Development Inventory: Words and Sentences (MCDI; Fenson et al., 2007; Jackson-Maldonado et al., 2003) to assess children's vocabulary knowledge, (b) the Language Mixing Scale (Byers-Heinlein, 2013) to measure children's exposure to mixed-language utterances, and (c) basic demographic questionnaires. Parents of all participants provided demographic information and estimates of children's global exposure to English versus Spanish, but only 16 parents provided MCDI data in the child's dominant language ($M$ = 237 words produced, $SD$ = 176, range: 57–611), 14 parents provided MCDI data in the child's non-dominant language ($M$ = 90 words, $SD$ = 79, range: 17–264), and 18 parents completed the Language Mixing Scale ($M$ = 17, $SD$ = 8.6, range: 0–30).

### 2.4 | Coding

Videos of children's eye movements were coded offline at 33 ms intervals by trained coders, blind to condition, for whether the child was looking at the left or right image, shifting between images, or off-task (Fernald, Zangl, Portillo, & Marchman, 2008). Trials were excluded if the child was not looking at either image at noun onset (4.5% of the dataset) or looked away for more than 500 ms continuously within the analysis window (22% of trials). To ensure reliability, 25% of the trials for 25% of participants were re-coded by a second coder. Coders agreed on gaze location on 98% of frames overall and agreed within a single frame on 98% of frames surrounding shift events.

## 3 | RESULTS

We assessed bilingual toddlers' comprehension by examining the accuracy with which they looked to the labeled target object. Accuracy was computed as the proportion of time children spent looking to the target divided by the total time looking at either image over a window of 367–2000 ms following the onset of the target noun (consistent with Byers-Heinlein et al., 2017). Mean accuracy was calculated for each participant for each of the four trial types. Mean accuracies were compared using a 2 x 2 repeated measures ANOVA (Sentence frame: dominant vs. non-dominant language; Trial type: Single-Language vs. Switched-Language). The ANOVA revealed no main effect of sentence frame ($F[1,19] = 2.66$, $p = 0.12$, $\eta_p^2 = 0.12$) or trial type ($F[1,19] = 0.40$, $p = 0.53$, $\eta_p^2 = 0.02$), suggesting children's performance was not better overall for one language over the other, and there was no global difference between single-language and mixed-language sentences. However, there was a significant interaction ($F[1,19] = 14.65$, $p = 0.001$, $\eta_p^2 = 0.43$, post-hoc power >0.99), suggesting that the difference between Single-Language and Switched-Language sentences differed for children hearing sentences in their dominant versus non-dominant language[2].

To better understand these effects, we performed planned comparisons using two-tailed paired-samples $t$-tests. When tested using sentence frames in their dominant language, toddlers showed significantly higher accuracy on Single-Language versus Switched-Language trials ($t[19] = 2.66$, $p = 0.02$, *Cohen's* $d = 0.60$), revealing a significant switch cost when listening to a change from a sentence frame in their dominant language to a label in their non-dominant language. Furthermore, single-sample $t$-tests revealed that performance was significantly above chance (0.5) for Single-Language trials ($M = 0.68$, $SE = 0.031$, $t[19] = 5.77$, $p < 0.0001$, $d = 1.29$), but not significantly different from chance on Switched-Language trials ($M = 0.55$, $SE = 0.039$, $t[19] = 1.36$, $p = 0.19$, $d = 0.30$). That is, when the sentence frame was in their dominant language, children had more difficulty in understanding a subsequent noun that was in their non-dominant language. On the other hand, when children were tested using sentence frames in their non-dominant language, there was no difference between trial types ($t[19] = 1.61$, $p = 0.12$, $d = 0.36$). Children performed above chance on both trial types, and in fact performed numerically better on Switched-Language trials (Single-Language: $M = 0.62$, $SE = 0.046$, $t[19] = 2.71$, $p = 0.01$, $d = 0.61$; Switched-Language: $M = 0.70$, $SE = 0.035$, $t[19] = 5.63$, $p < 0.0001$, $d = 1.26$). When children heard sentence frames in their non-dominant language, they recognized words with equal success when the word was also in the non-dominant language or switched to the dominant language. Thus, children showed no switch cost when hearing switches from their non-dominant to dominant language.

Inherent to mixed sentences is the presence of two parts: the language of the sentence frame, and the language of the target noun. Our initial ANOVA categorized trial types by sentence frame, but we re-classified trial types by the language used for the target noun, providing a different perspective on the same data. We re-ran the ANOVA, now focusing on the language of the target noun as well as trial type (Target noun: dominant vs. non-dominant label; Trial type: Single- vs. Switched-Language). This analysis showed a significant effect of target noun ($F[1,19] = 14.65$, $p = 0.001$, $\eta_p^2 = 0.43$), but no interaction ($F[1,19] = 2.66$, $p = 0.12$, $\eta_p^2 = 0.12$). Toddlers were significantly more accurate when objects were labeled in their dominant language across both Single-Language and Switched-Language trials (see Figure 1). To rule out the possibility that toddlers simply did not know the words in their non-dominant language, we performed a single-sample *t* test collapsing across Single- and Switched-Language trials and found that toddlers showed significant recognition of nouns produced in their non-dominant language ($M = 0.59$, $t[19] = 2.90$, $p = 0.009$, $d = 0.67$). These analyses emphasize that bilingual toddlers' recognition of familiar words in different language contexts is more robust when labels are produced in their dominant language.

Finally, we tested whether children's performance was related within or across languages. Preliminary correlations suggested that accuracy was related across the two languages within conditions (Single-Language: $r = 0.46$, 95% CI = [0.02, 0.75], Switched-Language: $r = 0.55$, 95% CI = [0.14, 0.80]). However, once we corrected for multiple comparisons using the Holm–Bonferroni method, we found no significant correlations between children's accuracy across the four types of trials ($p > 0.05$); children's ability to process sentences in one language was not significantly related to their processing of the other language. In addition, after correcting for multiple comparisons, we found no significant correlations between the questionnaire measures (vocabulary, exposure to mixing, proportion of exposure to each language) and performance on the Looking-While-Listening task (all *p*s >0.05). As one might expect, age was positively correlated with vocabulary in both the dominant ($r = 0.64$, 95% CI = [0.22, 0.86]) and non-dominant language ($r = 0.25$, 95% CI = [−0.32, 0.69]). Although the magnitude of these

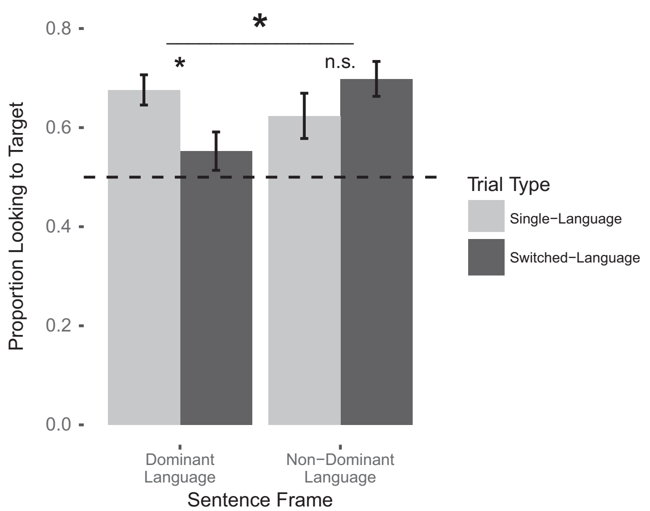


**FIGURE 1** Children's mean accuracy in looking to the target object from 367 to 2000 ms following noun onset, organized by the language of the Sentence Frame and by Trial type. Sentences that included a target noun in the dominant language are shown on the periphery (Dominant/Single-Language, Non-Dominant/Switched-Language), and sentences that included a target noun in the non-dominant language are shown in the center (Dominant/Switched-Language, Non-Dominant/Single-Language). Error bars indicate standard errors of the mean. Dashed line represents chance. Asterisks denote comparisons that are statistically significant ($p < 0.05$)

effects was moderate to large, the correlations were again not significant when we controlled for multiple comparisons[3]. Furthermore, age did not significantly predict real-time processing in either language. All data, along with stimuli, can be accessed on the Open Science Framework (https://osf.io/qp5wz/).

## 4 | DISCUSSION

This study tested whether Spanish–English bilingual toddlers' processing of single-language and switched-language sentences varied across their two languages. When toddlers were tested using sentence frames in their dominant language, they only displayed recognition of familiar words that were *also* presented in the dominant language, consistent with other reports that single-language sentences are processed more easily (Byers-Heinlein et al., 2017; Costa & Santesteban, 2004). However, when toddlers heard sentence frames in their non-dominant language, they successfully recognized target nouns in *both* languages. Viewed another way, toddlers recognized familiar nouns produced in their dominant language in both easy (Single-Language) and difficult (Switched-Language) utterances, but only demonstrated comprehension of labels produced in their non-dominant language if the whole sentence was produced in the non-dominant language. Thus, not all language switching impedes processing, and the robustness of bilingual toddlers' word knowledge influences their real-time comprehension of simple sentences.

These results expand our knowledge of how early bilinguals contend with language mixing. Byers-Heinlein et al. (2017) first reported that switch costs can be observed in infant bilinguals by testing 20-month-old Canadian French–English bilinguals. Here, we provide converging evidence with a new population: Spanish–English bilinguals in the United States. Previous studies using measures of parent report have suggested that language mixing affects children's vocabulary differently in different populations (Bail et al., 2015; Byers-Heinlein, 2013; Place & Hoff, 2016). While the current study did not find a clear relation between mixing and language outcomes, these results showed that Spanish–English bilingual infants, like French–English bilinguals, experience processing costs when switching from their dominant to non-dominant language. Toddlers from two different populations showed reduced accuracy in identifying referents following a language switch, providing evidence for the idea that young bilinguals represent their two languages in a differentiated manner (Byers-Heinlein, 2014).

The fact that children's processing was more robust in their dominant language adds to recent literature suggesting that bilinguals' early vocabulary depends on the balance of input they receive in each language (e.g., Marchman et al., 2017; Place & Hoff, 2011). We did not find significant associations between children's vocabulary and real-time processing (see Bergelson & Swingley, 2015; Pomper & Saffran, 2018 for other examples of inconsistent relations). This result may be an artifact of parents' difficulty estimating children's knowledge in two languages (e.g., Marchman et al., 2017), may reflect that within-language estimates of vocabulary are not appropriate for capturing between-language comprehension (e.g., Place & Hoff, 2011, 2016), or may be due to limitations in the precision with which we can quantify individual infants' vocabulary and/or real-time processing abilities (e.g., Trafimow, 2016). However, even without robust correlations, our dominance-related findings are consistent with the view that children's comprehension is affected by the frequency with which they hear words in a particular language. Furthermore, children's accurate comprehension of single-language sentences in both their languages, even under challenging circumstances, underscores the success with which they can acquire two languages simultaneously.

Critically, these results revealed that Spanish–English bilingual toddlers did not reliably identify referents when listening to switches from their dominant to non-dominant language, but did so successfully for the reverse direction. Prior accounts have stressed the role of broad cognitive control processes in language switching, as listeners may struggle to retrieve lexical items in the less active language (e.g., Byers-Heinlein et al., 2017; Green, 1998; Thomas & Allport, 2000). However, we suggest that our results are best explained by research examining how infants use experience to engage in predictive processing and how lexical knowledge develops in the first years of life.

Evidence from monolinguals suggests that infants are more efficient in processing familiar words following a common sentence frame (e.g., *Look at the*…) than when hearing words in isolation, as predictable frames afford listeners the opportunity to anticipate upcoming information (Fernald & Hurtado, 2006). Across many dimensions, predictability supports infants' word learning (e.g., Axelsson & Horst, 2014; Benitez & Smith, 2012), and prediction abilities are tied to vocabulary knowledge (Reuter, Emberson, Romberg, & Lew-Williams, 2018). On Switched-Language trials, it was presumably harder for toddlers to generate an accurate prediction about the upcoming label. With sentence frames in their dominant language, it is likely that they generated more predictions and were then less able to recover when the noun occurred in the non-dominant language, leading to impaired comprehension. On the other hand, children likely generated fewer or weaker predictions in their non-dominant language, and thus experienced a smaller disruption, which allowed them to accurately recognize the target noun. Given the presence of visual referents in the context of this experiment, which potentially constrained children's predictions about upcoming words, it will be important to test these ideas across a broader range of contexts, such as those without visual referents or those with more complex scenes.

A related framework for understanding the asymmetrical effects of switching is through the lens of statistical learning. That is, how well did sentences match the combinations of sounds and words in toddlers' prior experience? Infants track co-occurrences of sounds in their input at many levels (e.g., Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993; Maye, Werker, & Gerken, 2002; Pelucchi, Hay, & Saffran, 2009; Saffran, Aslin, & Newport, 1996) and can detect and exploit common phrase structures (e.g., Mintz, 2003). In bilingual contexts, single-language sentences are more common and conform to the statistics of infants' language experience better than mixed sentences (Byers-Heinlein, 2014; Goodz, 1989). Young children have often heard the combination *Do+you+like+the* (+ an English noun) and *Te+gusta+el* (+ a Spanish noun) and are, on average, less likely to hear these familiar sequences of words in conjunction with a word in the other language. Mixed sentences violate the predominant statistics of young bilinguals' language environments not only at the word level, but also with respect to sounds. For example, the "th" sound (as in *mouth*) is not used in Spanish, nor do English words contain the rolled "rr" found in *perro*. Therefore, a sentence that starts with English words such as *Do you like*… is unlikely to be followed by a word that contains a "rr" sound, meaning that hearing *perro* represents a mismatch on multiple dimensions. Through experience, bilingual toddlers learn that some combinations are more probable, which may contribute to the ease with which different sentences are processed (e.g., Bannard & Matthews, 2008).

While the language of the sentence frame undoubtedly contributed to the ease of processing, the main determinant of toddlers' comprehension was the language of the target noun. Independent of the linguistic context in which the label occurred, toddlers displayed better recognition of nouns that were produced in the language heard more often in their daily lives. Previous research has robustly shown that frequency of exposure supports monolingual children's early word learning (e.g., Goodman et al., 2008; Huttenlocher et al., 1991; Roy, Frank, & Roy, 2009), and high-frequency words are better remembered and recognized (e.g., Ambridge, Kidd, Rowland, & Theakston, 2015; Garlock, Walley, & Metsala, 2001). Bilingual toddlers, even by the second year, develop stronger representations of the words in their more frequently heard language (e.g., Singh, 2014), thereby enabling successful recognition of labels produced in their dominant language, regardless of sentence context.

In contrast, toddlers failed to demonstrate comprehension of target nouns in their non-dominant language after a switch, although they successfully recognized those same nouns in single-language sentences. When toddlers have weak representations of a word, both bilinguals and monolinguals may rely on familiar contexts to demonstrate their knowledge (e.g., Mattock, Polka, Rvachew, & Krehm, 2010). Toddlers' greater difficulty in demonstrating comprehension of words in their non-dominant language suggests that more fragile items are better recognized in "easy," supportive sentences, that is, those with no violations of previously learned sound/word co-occurrences. In this sense, if we tested them on lower-frequency words in their dominant language, they might only show comprehension in a single-language utterance. Similarly, in unusual sentence contexts, monolingual children would potentially be able to display their knowledge of higher-frequency items, but not lower-frequency items. These predictions remain to be tested.

Using explanations based on toddlers' knowledge of statistical regularities and representations of individual words, we can explain performance on each of the trial types. On Single-Language trials in their dominant language, toddlers could demonstrate comprehension thanks to both consistent statistics and stronger lexical representations. On Single-Language trials in their non-dominant language, they could rely on consistent statistics despite weaker representations. On Switched-Language trials from their non-dominant to dominant language, statistics were violated, but toddlers could rely on their robust representations of nouns. However, with a switch from their dominant to non-dominant language, toddlers failed to show comprehension because statistics were violated and their representations were not strong enough to compensate. Together, these four conditions highlight how different types of knowledge – statistical learning and lexical representations – interact in early language processing.

Word representations emerge gradually, and toddlers' knowledge is not all-or-none (e.g., Bion, Borovsky, & Fernald, 2013; Perry & Saffran, 2017). By testing how bilingual infants separate and coordinate between languages, this study offers a key demonstration of this principle. We tested the same participants on the same items, under easier and more difficult conditions, in two different languages – and in doing so, we held child-specific factors constant such as age, cognitive and perceptual abilities, interest in the task, and knowledge of the referents (e.g., dogs and balloons). With this design, we can conclude that performance across trial types emerged from differences in language experience and word knowledge. Under easier conditions, toddlers' comprehension was relatively similar across languages. However, the relatively challenging context of a language switch disrupted sentence processing, and toddlers' understanding of their non-dominant language was revealed to be more fragile. These findings reveal a fundamental commonality between monolingual and bilingual learning: the strength of children's knowledge about a word and its links to other words affects their ability to recognize it in diverse contexts.

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## CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

## ENDNOTES

[1]Five participants were tested in a quiet location in a community center, rather than in a lab setting. These participants were also seated on their parents' lap, while parents wore opaque sunglasses. The procedures were identical, except that toddlers viewed images on a 13" laptop screen and listened to stimuli over noise-canceling headphones.

[2]To ensure that there were no differences across our two testing sites, we performed this same ANOVA with data only from the subset of children tested in the main lab. That analysis also revealed a significant interaction between Sentence frame and Trial type [$F(1, 14) = 5.33$, $p = 0.04$, $\eta_p^2 = 0.28$], showing that including children tested in the community lab did not change the pattern of results.

[3]We initially corrected for multiple comparisons using the Bonferroni method and found no significant relations. However, because this approach is quite conservative, we then used the less stringent False Discovery Rate method, but still did not find significant correlations.

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