Vois-tu le *kem*? Do you see the *bos*? Foreign word learning at 14-months

Chelsea da Estrela & Krista Byers-Heinlein

Concordia University

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Correspondence concerning this article should be addressed to: Chelsea da Estrela, Department of Psychology, Concordia University, 7141 Sherbrooke St. West, Montreal, QC, Canada, H4B 1R6. E-mail: c_daestr@alcor.concordia.ca

Abstract

How easily can infants regularly exposed to only one language begin to acquire a second one? In three experiments, we tested 14-month-old English and French monolingual infants' ability to learn words presented in foreign language sentence frames. Infants were trained on two novel word-object pairings, then tested using a preferential looking task. Word forms were phonetically and phonotactically legal in both languages, and cross-spliced across conditions, so only the sentence frames established the word as native or foreign. In Experiment 1, infants were taught one native and one foreign word, and successfully learned both. In Experiments 2 and 3, infants were taught two foreign words, but only showed successful learning of the first word they encountered. These results demonstrate that infants can successfully learn words embedded in foreign language sentences, but this is more challenging than native word learning. More broadly, they show that the sentential context of a novel word, and not just the word form itself, influences infants' early word learning.

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As the world becomes increasingly multilingual, investigations into how individuals come to acquire new languages is of interest to both researchers and the public at large. While some individuals acquire a second language in middle childhood, adolescence, or adulthood, many children are exposed to a new language in daycare and other early childhood education settings. In large North American cities, upwards of 27% of children in daycare will be exposed to a language other than the one they are hearing at home (Chumak-Horbatsch, 2010). But how do infants initially exposed to only one language begin to acquire a second one? Specifically, how easily can infants learn foreign language words?

Foreign word learning likely draws on many of the same capacities that support native word learning, and infants are remarkable word learners. Laboratory studies have shown that 12-14 month-old infants can rapidly form word-object associations (MacKenzie, Curtin, & Graham, 2012a; 2012b; Werker, Cohen, Lloyd, Casasola, & Stager, 1998). That is, even before infants can reliably produce words (Nazzi & Bertoncini, 2003), they are able to associate a label with its referent. Following repeated pairings of two isolated nonsense word with two novel objects (e.g., the nonsense words *lif* with object A, and *neem* with object B), 14- but not 8-month-olds noticed when the word previously paired with one object was suddenly paired with the other object (Werker et al., 1998). Infants' precocious ability to associate a word and its referent has been shown in dozens of other laboratory studies (e.g., Byers-Heinlein, Fennell, & Werker, 2013; MacKenzie, Graham, & Curtin, 2011; Schafer & Plunkett, 1998).

How is learning foreign language words different from learning native language words? One important difference is the form of the word itself. Words are built from sounds and sound combinations that vary across languages. Infants begin tuning into their language's sound systems from very early in life in a process called perceptual narrowing. While newborn infants are sensitive to nearly all meaningful sound contrasts that exist in the world's languages, between 6 and 12 months they lose sensitivity to non-native sound contrasts (Werker & Tees, 1984) while gaining sensitivity to native sound contrasts (Kuhl et al., 2008). They also become attuned to the phonotactic patterns characteristic of their native language, which make some sound combinations legal and others illegal (Jusczyk & Aslin, 1995; Jusczyk, Luce, & Charles-Luce, 1994). These early perceptual skills are foundational to later word learning, as they allow infants to efficiently process and encode native language words (Werker & Yeung, 2005). However, perceptual narrowing could also be challenging for learning foreign word forms, as infants lose sensitivity to and interest in sounds and sound patterns that do not conform to their native language.

A number of studies have directly investigated infants' ability to learn word forms that are atypical of those in their native language. In a study with 12-month-olds, English-learning infants readily associated novel consonant-vowel-consonant (CVC) words (e.g., *wug* and *fep*) with novel objects but did not do so for other linguistic sounds (e.g., *ooh* and *aah*). The authors posited that young infants recognize what constitutes typical native language word forms, and are only willing to treat such forms as object labels (MacKenzie et al., 2011). In another study, English-learning infants failed to learn word-object associations when taught a minimal pair whose key contrast was meaningful in

Dutch but not in English (e.g., *tam* and *taam*), even though infants could hear the difference between the two words when tested in a speech perception task (Dietrich, Swingle, & Werker, 2007). Together, these studies strongly suggest that foreign words whose form is atypical of infants' native language might be particularly difficult for them to learn.

Although several studies have presented infants with foreign-sounding words in isolation, in everyday contexts, foreign language words are embedded in foreign language sentences. This points to two potential challenges for the infant: the foreign word form itself, and also its situation in a foreign language sentence. These challenges can be independent from each other, as even if the form of the target foreign word itself is phonetically and phonotactically typical of the native language, its surrounding context can still be foreign. While several studies have examined how easily infants can adapt to foreign language word forms, fewer studies have asked whether the simple presence of a foreign language sentence frame also affects word learning.

Several studies have investigated this possibility indirectly by teaching children foreign language words in naturalistic contexts. In a study with 20-month-olds, French monolingual infants were taught English pseudowords for novel objects by a bilingual English-French speaker using English language sentence frames (e.g., "Do you want to play with the *chook*?"; Bijeljac-Babic, Nassurally, Havy, & Nazzi, 2009). Infants showed evidence of successful word learning after only four training trials, suggesting that they had little difficulty in this word learning situation. Several similar studies have also been undertaken with older children, with mixed results. In a study where a live actor taught three- and four-year-olds nonsense words in made-up language sentence frames, only

children who had been previously exposed to a second language were able to learn the words (Akhtar, Menjivar, Hoicka, & Sabbagh, 2012). In a study with two-year-olds, only toddlers with high vocabularies in their native language were able to learn foreign nonsense words embedded in foreign language sentence frames (Koenig & Woodward, 2012).

One limitation of these naturalistic studies is that they could not isolate the effects of the foreign word form from the effects of the foreign sentence frame. Yet, drawing from studies using native language sentence frames, there is strong evidence that sentence frames influence infants' early word learning. For instance, 18-month-old hearing infants with no previous exposure to sign language will treat gestures embedded in spoken sentence frames as labels for novel objects (Namy & Waxman, 1998). Similarly, 13-month-olds will do the same with nonlinguistic sounds embedded in native language sentences (e.g., an electronic beeper or squeak from a rubber toy; Woodward & Hoyne, 1999). In contrast, in studies where foreign nonsense words are taught in isolation (i.e., in the absence of native language sentence frames), infants do not show successful word learning (MacKenzie et al., 2011).

To date, no studies have specifically investigated the impact of foreign language sentence frames on early word learning. As such, this paper reports a series of three experiments that explicitly tested 14-month-old infants' ability to learn words presented in a foreign language context. To maximize experimental control of the stimuli, our study used video stimuli in an eye tracking paradigm, rather than a live experimenter. We isolated the effects of foreign language sentence frames by teaching infants nonsense words that were phonetically and phonotactically legal in both the native language and

the foreign language. We hypothesized that, even with a native-like word form, foreign language sentence frames themselves would challenge the young word learner. Thus, we predicted that young word learners would show difficulty in learning words embedded in foreign language sentence frames.

Experiment 1

Experiment 1 used a within-subjects design to compare 14-month-old monolingual infants' learning of a word embedded in foreign language sentence frames to their learning of a word embedded in native language sentence frames. Importantly, the word form itself was kept constant, by selecting a target word form that was phonetically and phonotactically legal in both the native and foreign languages, and counterbalancing and cross-splicing the same token into sentences from both languages. We tested 14-month-olds because, at this age, infants can reliably learn novel words in a laboratory setting (Byers-Heinlein et al., 2013; MacKenzie et al., 2012a; 2012b; Schafer & Plunkett, 1998; Werker et al., 1998). Infants were trained on two novel word-object pairings, one in native sentence frames and one in foreign sentence frames. Following the training phase, both objects appeared side-by-side and one of the taught words was heard in isolation. Proportion looking time at the target object was used as an index of word learning, with target looking time greater than chance interpreted to mean successful word learning. Based on the hypothesis that foreign language sentence frames would be challenging, we predicted that infants would learn the native language word but not the foreign language word.

Method

Participants. Sixteen 14-month-old infants ($M = 14m15d$, range: 14m0d to 15m1d), 8 boys and 8 girls, completed the study. Participants were all monolingual, learning either French ($n = 8$) or English ($n = 8$) from birth, with no more than 5% exposure to a second language as measured by the Language Exposure Questionnaire (Bosch & Sebastián-Gallés, 2001). An additional 6 infants were tested but excluded from the final sample because of technical difficulties (4) and fussiness (2). All infants were recruited through birth lists provided by the Régie régionale de la santé et des services sociaux de la région de Montréal-Centre.

Apparatus. A Tobii T60XL eye tracking system and Tobii Studio software were used for data collection. Stimuli were presented on a 24" monitor that included a built-in camera to capture and record the infants' eye gaze. An infrared light shone on the infants' eyes creating a reflection pattern that was then captured by the camera.

Stimuli. The visual stimuli consisted of images of two novel objects against black backgrounds, "crown" and "molecule" (see Figure 1). A 10 second video of a pinwheel spinning at a variable rate against a black background was shown prior to the first training trial and after the last trial of the study. The video was accompanied by a non-linguistic spinning sound. Similar visual stimuli have been used in numerous previous studies of infant word learning (e.g., Fennell, Byers-Heinlein, & Werker, 2007; MacKenzie et al., 2011; Werker, Fennell, Corcoran, & Stager, 2002).

The auditory stimuli included exemplars of two nonsense words: *bos* (/bos/) and *kem* (/kɛm/). These words were chosen as they are comprised of phonemes found in both English and French, and they have been used in previous studies of word learning in French-English bilingual infants (Fennell & Byers-Heinlein, 2014; Mattock, Polka,

Rvachew, & Krehm, 2010). The stimuli were recorded from a native bilingual English-French female who did not have a perceptible accent in either language. Stimuli were produced using infant-directed speech. To ensure that the only foreign element of the training phase was the sentence frames and not the novel word itself (as elaborated below), the speaker was instructed to pronounce the labels in a manner intermediate to English and French. An informal survey of native English and French speaking adults confirmed that the words were indeed perceived as native in both languages. A total of six different tokens of each novel word were selected; three used in the training phase and three used in the test phase. Each individual token was approximately 0.7 seconds in duration.

In each English training trial, three different tokens of one novel word were preceded by three different English sentence frames (“*Look it’s the _____*”, “*Do you see the _____*”, “*I like the _____*”). In each French training trial, the other word was preceded by three different French sentence frames (“*Regarde c’est le _____*”, “*Vois-tu le _____*”, “*J’aime le _____*”). The original recordings were spliced such that an identical token of the exemplar was used in both languages of a given carrier phrase. The four versions of each carrier phrase (e.g., *Look it’s the kem! Regarde c’est le kem! Look it’s the bos! Regarde c’est le bos!*) were matched for prosody and length to minimize differences between the sentences. To account for effects of co-articulation, different recordings of the same carrier phrase for each novel word were used.

Training trials began with a video of one of the novel objects looming at a constant rate in the middle of a black background. The visual stimulus appeared for 1.5 seconds before the onset of the initial carrier phrase, and a 1.5 second interval of silence

followed each carrier phrase. Although the audio and visual stimuli were presented simultaneously, the looming of the visual stimulus was not synchronized with the presentation of the audio stimulus (Gogate & Bahrick, 1998). The total duration of each training trial was approximately 11 seconds.

Auditory stimuli for each test trial consisted of three isolated tokens of one of the two novel words. Similar to the recordings used during the training phase, the *bos* and *kem* soundtracks were matched on prosody and length. Each test trial began with a stationary image of both novel objects appearing side by side against a black background. Following Schafer and Plunkett (1998), the image appeared for 3 seconds before the onset of the first token and a period of 1.5 seconds of silence followed each token. Two versions of each test trial were created that counterbalanced the side of presentation of the two objects.

Procedure. Infants were seated on their parent's lap approximately 60 cm away from the eye tracker screen in a soundproof room. Before the stimuli were presented, the eye tracker was calibrated to the infant's eyes using a built-in five-point calibration routine. Once calibration was completed, the parent was instructed to remain neutral and to keep the infant in the same position. The parent wore darkened sunglasses and listened to music on headphones to avoid influencing the infant's natural reactions. An attention-grabbing animation of a circle stretching and changing colors was presented between trials to recapture the infant's attention.

Each infant was presented with a total of 16 training trials: eight *bos*-crown trials and eight *kem*-molecule trials. One novel word was presented in English sentence frames and one novel word was presented in French sentence frames. As the infants tested in the

current study were English and French monolinguals, this meant that each infant was taught one word in their native language and one word in a foreign language. Further, the stimuli that were native for half of the infants were foreign for the other half of the infants, providing an internal control. Following the training phase, each infant was presented with four test trials, two trials per novel word.

Infants were assigned to one of eight experimental orders, which counterbalanced the order of the training trials and the language of the sentence frames the novel words were embedded in (i.e., in half the orders *kem* was presented in English sentences and in the other half *kem* was presented in French sentences). The two types of training trials were presented in a pseudo-random order such that infants did not hear the same trial type repeated more than twice in a row. Similarly, test trials were ordered to ensure that infants could not develop a response strategy. Trials always occurred in a variation of the order Word A – Word B – Word B – Word A, with *kem* acting as Word A for half of infants, and *bos* acting as Word A for the other half of the infants. The side of presentation of the two objects on test trials was counterbalanced both within and between infants. An example of the complete experimental design is depicted in Figure 1.

The total duration of the study was approximately 5 minutes, after which parents completed either the American English (Fenson et al., 2007) or the Quebec French (Boudreault, Cabirol, Trudeau, Poulin-Dubois, & Sutton, 2007) Words and Gestures version of the MacArthur-Bates Communicative Development Inventory to obtain a measure of each infant's receptive and expressive vocabulary size in their native language. Upon completion of the study, the infants were given a certificate and a t-shirt for their participation.

Results

Tobii Studio software was used to extract and summarize the eye tracking data. For training trials, total looking time during the eight native language training trials and eight foreign language training trials were each summed to create a total looking time score for each trial type (native trials and foreign trials). For test trials, data were summarized by calculating the proportion looking time at the target object on each of the four test trials. Proportion looking time at the target object was calculated by dividing the total fixation duration at the target object by the sum of the total fixation duration at both the target and the distractor object. The window of analysis was set to 200ms after the onset of the first target word until the end of the trial. Test trials with less than 750ms of looking time data at the objects during the specified window of analysis were excluded. Using this criterion, a total of 16% of test trials were excluded. All infants had at least one data point for each type of test trial. Proportion looking time to the target object on the two native language and two foreign language test trials were averaged together, yielding a single measure of proportion looking time for each test type (i.e., native or foreign) for every participant.

A first set of preliminary analyses investigated infants' interest in the native and foreign language words during training, by computing their total looking time at each object during training. Infants showed very similar interest in the native language training trials ($M = 43.24$, $SD = 22.70$) and the foreign language training trials ($M = 42.22$, $SD = 19.61$), $t(15) = .30$, $p = .766$, $d = .08$. This ruled out the possibility that any differences seen at test would be due to different attention to the two types of words during training. A second set of preliminary analyses explored effects of infant language background and

sex on infants' looking time at test. A 2 (language background; French, English) x 2 (sex: male, female) x 2 (trial type: native, foreign) ANOVA showed no main effects or interactions. Thus, language background and sex were excluded from subsequent analyses.

To test the main hypothesis a two-tailed single-sample *t*-test was conducted for each trial type (i.e., native and foreign) to compare the proportion looking time to the target object to chance (.50). Results are illustrated in Figure 2. Contrary to hypotheses, infants showed successful learning on both the native and the foreign trials. Infants looked at the target above chance on both the native language trials ($M = .61$, $SD = .19$), $t(15) = 2.43$, $p = .028$, $d = 1.25$ and the foreign language trials ($M = .61$, $SD = .20$), $t(15) = 2.31$, $p = .036$, $d = 1.19$. Looking times during the two trial types were not statistically significantly different from each other $t(15) = .07$, $p = .947$, $d = .02$.

Finally, exploratory analyses investigated the relation between participant characteristics (age, receptive vocabulary, and expressive vocabulary) and performance on the two types of test trials using bivariate correlations. There were no statistically significant correlations between any of these variables.

Discussion

Experiment 1 compared 14-month-old infants' ability to associate an object with a word presented in foreign language sentence frames versus one presented in native language sentence frames. While we predicted that infants would show better learning of the word embedded in the native language sentence frames than the word embedded in the foreign language sentence frames, infants showed successful and equivalent learning of both types of words.

Although not entirely inconsistent with previous research (e.g., Bijeljac-Babic et al., 2009), this result is nonetheless surprising. Why were infants so successful at learning the foreign language word? There are several possibilities. One possibility is the intensive training infants received on each word was sufficient to overcome any potential difficulties with foreign word learning. Importantly, the target word was always presented in a salient, sentence-final position, which has been shown to facilitate both word segmentation and word learning (Seidl & Johnson, 2006; Shukla, White, & Aslin, 2011). Further, each infant heard the foreign word paired with the object 24 times. Young infants readily make associations between isolated words and objects, and these regularities were plentiful in the current study. Indeed, some researchers argue that such associative information alone is sufficient to support early word learning (Nazzi & Bertoncini, 2003). In sum, infants may have succeeded simply by detecting regularities between the target word and object, perhaps even ignoring the sentence frame altogether.

When considering infants' success in this experiment, it is also important to note that our stimuli were produced by a bilingual speaker. Two previous studies of minimal pair word learning have shown that monolingual infants have more difficulty learning minimal pairs produced by a bilingual speaker than minimal pairs produced by a monolingual speaker (e.g. *bos* and *gos*; Fennell & Byers-Heinlein, 2014; Mattock et al., 2010). Given that monolinguals in this experiment did not have difficulty learning the words, this suggests that a speaker's status as a monolingual or bilingual might be less relevant when infants are learning dissimilar-sounding words than when they are learning a minimal pair.

A final factor contributing to infants' success in the current experiment might be that, in our experiment, infants were taught the foreign word at the same time as a native language word. It might be that the presence of the native word supported the learning of the foreign word, for example by providing infants with clear cues that they were in a word learning situation, or by clarifying where the target word occurred within the carrier phrases. Experiment 2 was designed to tease apart these possibilities. If infants learned the foreign word simply through their sensitivity to associative regularities, they should be able to learn two foreign words as easily as they learned one native and one foreign word. In contrast, if the native language word supported learning of the foreign language word, then infants should fail to learn foreign words when no native language word is being taught.

Experiment 2

To investigate infants' foreign word learning capabilities in the absence of any native language context, Experiment 2 tested 14-month-old monolingual infants' ability to learn two words each embedded in foreign language sentence frames. If the regularities between the words and the objects in Experiment 1 were sufficient for successful word learning, then infants should also learn both words in Experiment 2, as the associative regularities in both experiments are identical. However, if the native language condition in Experiment 1 facilitated learning in the foreign language condition, then infants should fail to learn the words in Experiment 2. Consistent with the latter explanation, we predicted that if both words were taught in foreign language sentence frames, infants would fail to form a word-object association for either pair.

Method

Participants. Sixteen 14-month-old infants ($M = 14\text{m}14\text{d}$, range: 13m22d to 15m8d), 6 boys and 10 girls, completed the current study. Similar to Experiment 1, participants were all monolingual, learning either French ($n = 9$) or English ($n = 7$) with no more than 5% exposure to a second language. An additional 11 infants were tested and excluded from the final sample because of fussiness (9), technical difficulties (1), and missing questionnaire data (1).

Procedure. Experiment 2 was nearly identical to Experiment 1, except that during training, both words were embedded in foreign language sentence frames. Therefore, English-learning infants heard both novel words embedded in French sentence frames while French-learning infants heard both novel words embedded in English sentence frames. Infants were randomly assigned to one of eight trial orders, which paralleled the orders used in Experiment 1. As such, during training, half the infants saw the *bos*-crown pairing first and half the infants saw the *kem*-molecule pairing first. Just as in Experiment 1, on subsequent training trials, the two pairings alternated in a pseudo-random fashion such that neither word was presented more than twice in a row. The test trials were identical to Experiment 1: the two objects were shown side by side, and the target words were presented in isolation.

Results

Data were analyzed as similarly as possible to Experiment 1. However, because in this experiment both words were foreign, they were distinguished by whether they were presented first or second in the training phase. Because of counterbalancing, the first pairing was *bos*-crown for half of the infants, and *kem*-molecule for the other half of

the infants. 11% of test trials were excluded from the analyses because of low looking time (less than 750 milliseconds of looking time).

As in Experiment 1, preliminary analyses investigated infants' interest in each word during training by computing their total looking time at each object during this phase of the experiment. Infants showed very similar interest in the first word-object pair ($M = 42.48$, $SD = 20.67$) and the second word-object pair ($M = 39.85$, $SD = 18.40$), $t(15) = .75$, $p = .467$, $d = .19$. This ruled out the possibility that any differences seen at test would be due to systematic differences in attention to the two word-object pairs during training. As in Experiment 1, preliminary ANOVAs investigated potential effects of infants' language background and sex on infants' looking time at test. Again, no main effects or interactions were found with these factors, and thus they were excluded from further analyses.

To test the main hypothesis, a two-tailed single-sample t -test was conducted for each trial type (i.e., first word-object pairing and second word-object pairing) to compare the proportion looking time to the target object to chance (.50). Infants looked at the target above chance on the first word-object pairing trial type ($M = .60$, $SD = .16$), $t(15) = 2.55$, $p = .022$, $d = .63$, but not on the second word-object pairing trial type ($M = .49$, $SD = .26$), $t(15) = -.21$, $p = .839$, $d = .04$. Thus, infants successfully learned the first word-object pairing, but failed to learn the second word-object pairing. The two trial types were not statistically significantly different from each other, $t(15) = .11$, $p = .153$, $d = .37$.

Refer to Figure 2 for an illustrated depiction of the results.

As in Experiment 1, there were no statistically significant relations between any of the participant characteristics and looking patterns at test.

Discussion

Experiment 2 examined 14-month-old infants' ability to learn two words embedded in foreign language sentence frames. This study tested two competing hypotheses. If infants' sensitivity to associative regularities can support foreign word learning as easily as native word learning, then infants should have learned both words in our task. In contrast, if the presence of the native language words in Experiment 1 guided infants' learning, then infants should have learned neither word in our task. Surprisingly, we found neither of these results. Instead, infants learned only one of the two word-object pairings, the first word-object pair they encountered. This was not attributable to different attention to the two pairings, as infants attended similarly to both word-object pairings during training. Further, it could not be explained by a simple object bias at test, as infants were above chance on one word, but at chance (and not below) on the other word.

Our results rule out strong versions of both of the hypotheses that we had raised. Associative regularities alone are not sufficient to support foreign word learning at this age. These regularities were identical in Experiments 1 and 2, yet infants were able to learn two words in Experiment 1 but only one word in Experiment 2. At the same time, these results also show that native language support is not necessary for foreign word learning, as infants did learn one of the two foreign words despite all training being in a foreign language.

These results are consistent with our initial prediction that foreign language sentence frames somewhat challenge the young word learner, although not to the degree that we had expected. Numerous previous studies have shown that infants of this age can learn two novel word-object pairings in experimental settings when the words are

presented in isolation (Byers-Heinlein et al., 2013; MacKenzie et al., 2011; Schafer & Plunkett, 1998; Werker et al., 1998). Further, they succeeded in learning two words in Experiment 1, where one word was embedded in a native sentence and one word was embedded in a foreign sentence. However, in the current experiment, where both words were presented in foreign sentence frames, infants only successfully learned one word. Young word learners are thus sensitive to the linguistic context within which words are taught. When that context does not match their native language it may interfere with their word learning, even when the form of the word itself is not foreign.

When comparing the findings from Experiment 1 and 2 it is still unclear exactly why infants learned both words in Experiment 1, but only one of the words in Experiment 2. One possibility is that infants are only able to learn one foreign word at a time in this type of paradigm; in both Experiments 1 and 2, infants only showed learning of one foreign language word. It is also possible that the native language input cued the infants to the task demands of the study, allowing them to learn two words. Specifically, the presence of the native language sentence frame could have clarified the nature of the word-learning task at hand. If the latter explanation is true, infants might be able to learn two foreign words if they are provided with clearer referential cues that the objects onscreen are being named. This possibility was examined in Experiment 3, by preceding the training phase with a referential familiarization phase wherein infants heard labels for familiar objects in their native language. Previous studies have used this same manipulation, which has been shown to boost word learning (Fennell & Waxman, 2010; May & Werker, 2014).

Experiment 3

Experiment 3 attempted to clarify the word-learning situation for infants, by introducing a manipulation wherein infants saw familiar objects named in their native language prior to the training phase. Previous studies have shown that this manipulation can boost word learning to support word learning in challenging word learning situations (e.g., teaching infants minimal pairs like *bos* and *gos*; Fennell & Waxman, 2010; May & Werker, 2014). If the native language sentence frames in Experiment 1 enhanced foreign word learning, then infants should be able to learn both foreign words in the current study. Given previous research showing that infants are flexible word learners who are capable of learning foreign word forms in studies rich in contextual cues, we predicted that infants would be able to learn both foreign words given this additional contextual support.

Method

Participants. Sixteen 14-month-old infants completed Experiment 3 ($M = 14m9d$, $range = 13m23d$ to $14m28d$), 7 girls and 9 boys. Consistent with the language criteria in the previous two experiments, participants were monolingual infants, learning either French ($n = 6$) or English ($n = 10$). An additional 19 infants were tested but excluded because of fussiness ($n = 12$), technical difficulties ($n = 6$), and parental interference ($n = 1$). The attrition rate was somewhat higher than in the previous two experiments, which might be because the referential familiarization phased increased length of the procedure.

Procedure. Experiment 3 followed the procedure described in Experiment 2, with the addition of the referential familiarization phase. Similar to the procedure used in Fennell and Waxman (2010) and May & Werker (2014), prior to the training phase

infants were presented three referential familiarization trials that labeled familiar objects in their native language.

The stimuli used in the referential familiarization phase consisted of three videos, each of a highly familiar object (a dog, a shoe, and an apple) looming against a black background. These objects were chosen because their labels were phonetically dissimilar to the test words and they are likely to be understood by 14-month-olds. In each video, the objects were labelled three times in isolation. The words in the referential training phase were not embedded in sentence frames so as to provide referential cues from the native language (i.e., that objects would be labeled), while avoiding additional sentential cues. The objects were either labelled in English or French (*chien*, *soulier*, and *pomme*), whichever language was native to the participant. The tokens were recorded by the same bilingual speaker who recorded the stimuli in Experiments 1 and 2. Similar to the training and test stimuli, the tokens were matched for prosody and length across the two languages. As in the training phase, the objects appeared on the screen for 1.5 seconds of silence before the onset of the first token and there was 1.5 seconds of silence following each token.

Following the referential familiarization phase, the experiment proceeded identically to Experiment 2. That is, infants were taught two novel word-object pairings embedded in foreign language sentences. Eight orders were created that paralleled those used in Experiments 1 and 2.

Results

Following the data analyses conducted in Experiment 2, the data in Experiment 3 were analyzed separately for the first and the second word-object pairing that infants

encountered during training. Test trials with less than 750 milliseconds of looking time were excluded from the analyses (16% of the test trials).

As in the first two experiments, preliminary analyses investigated infants' total looking time at each object during the training phase of the experiment. Infants showed very similar interest in the first word-object pair ($M = 37.78$, $SD = 21.74$) and the second word-object pair ($M = 37.07$, $SD = 16.55$), $t(15) = .20$, $p = .842$, $d = .06$. Therefore, any differences seen at test could not be attributed to differences in attention to each word-object pair during training. As in the previous experiments, preliminary ANOVAs revealed no main effects of language background or sex, or interactions with either factor and word order, on test performance.

To test the main hypothesis, a two-tailed single-sample t -test was conducted for each test type (i.e., first word-object pair and second word-object pair) to compare the proportion looking time to the target object to chance (.50). Infants looked at the target above chance on the first word-object pair ($M = .61$, $SD = .15$), $t(15) = 2.80$, $p = .014$, $d = .73$ but were at chance on second word-object pair ($M = .50$, $SD = .20$), $t(15) = -.03$, $p = .975$, $d = .05$. Once again, infants successfully learned the first word they had encountered, but not the second word. The two trial types were not statistically significantly different from each other, $t(15) = 1.41$, $p = .178$, $d = .35$. See Figure 2 for a visual depiction of the results.

Consistent with the results from Experiment 1 and 2, bivariate correlations between the participant characteristics and the variables of interest were not statistically significant.

Discussion

Experiment 3 tested whether a referential familiarization phase, wherein familiar objects were labeled in the native language, would support 14-month-olds in learning two words embedded in foreign language sentence frames. Contrary to our predictions that this manipulation would boost foreign word learning, infants performed identically in Experiment 3 as they had in Experiment 2, only learning the first word-object pair they encountered. This result was surprising, given that several studies have previously found that a referential training phase boosts word learning in challenging laboratory tasks (Fennell & Waxman, 2010; May & Werker, 2014).

General Discussion

In a series of three experiments, we investigated 14-month-old infants' ability to learn words embedded in foreign language sentence frames. Infants were taught one native and one foreign word (Experiment 1) or two foreign words (Experiments 2 and 3), then tested using a preferential looking task. We predicted that foreign word learning would be particularly challenging for infants of this age, and this prediction was partially supported. In Experiment 1, infants successfully learned one native and one foreign word. However, in Experiments 2 and 3, they only demonstrated learning of one of two foreign words (the first one encountered during training). Foreign word learning was not boosted by a referential pre-training phase, wherein familiar objects were labeled in the native language (Experiment 3). In sum, across three experiments infants could successfully learn one foreign language word, but could not learn two. This contrasts with other studies showing that infants can learn up to two words in a similar paradigm, if words are presented in isolation or in native sentence frames (e.g., Byers-Heinlein et al., 2013; MacKenzie et al., 2011; Schafer & Plunkett, 1998; Werker et al., 1998). Our results

suggest that infants do have some ability to learn words embedded in foreign language sentence frames, but that foreign word learning is nonetheless more difficult than native word learning.

Precisely how the foreign language sentence frames affected infants' word learning remains an open question. One inherent challenge of learning a word presented in foreign language sentences is that the semantic meaning of the sentence is opaque to the word learner. Native language sentences, but not foreign language sentences, may provide the infant with contextual and referential cues, for example by clearly indicating to infants that they are in a word learning situation and drawing attention in a familiar way to the to-be-learned word. Although Experiment 3 did provide infants with some referential cues in a pre-training phase, the lack of such cues during word learning itself could have impeded their success.

A second challenge for the infants could be that the foreign language sentences contained sound combinations and phonemes that are not found in their native language. As young word learners' vocabularies grow, they become more resistant to learning words with sound patterns that do not match the sounds found in their native language (Graf Estes, Edwards, & Saffran, 2011). While such a strategy may facilitate native language word learning, it would do so at the expense of foreign language learning. Although in our study the foreign sounds were in the sentences frames and not the target words themselves, this might nonetheless have engendered extra processing challenges.

A final possibility is that infants had trouble parsing out the target words from the foreign language sentence frames. However, there are several reasons that this explanation is unlikely. The target words always appeared in the sentence final position,

which should make it easier for infants to locate these words and parse them out of the sentence frames (Johnson, Seidl, & Tyler, 2014). Further, the target word was the only word that was repeated within a given familiarization trial, making it fairly salient. Finally, given that infants were able to learn some foreign language words, this would suggest that they were capable of detecting the target word.

Given the current set of experiments, which of these three factors disrupted word learning is not known, and it is possible that several different factors contributed to the infants' difficulties. To disentangle these effects, future studies could teach infants words embedded in nonsensical sentences that are semantically opaque but contain only native language sounds.

At the same time as understanding the challenges of foreign word learning, it is also important to consider why infants performed as well as they did in the current experiments, showing a circumscribed ability to learn words embedded in foreign language sentences. Our experimental design provided infants with many cues that would potentially support foreign word learning: the form of the words were phonetically and phonotactically legal in the native language, the target word was presented at the end of the sentence, and (in Experiment 3) infants were provided with contextual native language support during a referential familiarization phase. While these features of our experimental design likely supported infants' partial success, they did not render foreign word learning as easy as native word learning.

An additional feature of our studies was that associative regularities between the word and the object were robust and plentiful (infants heard each word-object pairing 24 times), and consistent across native language and foreign language conditions. Therefore,

these findings would suggest that while associative regularities may be important, and could have contributed to infants' partial success, they are not sufficient for word learning at this age. Instead, infants are sensitive to the context within which words are taught and this context influences their willingness to form word-object associations. This is consistent with previous research demonstrating that young word learners will accept a broad range of sounds and symbols as words but only under highly referential conditions (e.g., May & Werker, 2014; Namy, 2001). While Experiment 3 attempted to boost word learning by providing additional referential cues in a pre-training phase, infants may need even more support when encountering foreign language sentences.

In sum, foreign language sentence frames may be a double-edged sword for infants. There is evidence that sentence frames generally facilitate word learning, for example in learning of minimal pair words (e.g., *bin* and *din*; Fennell & Waxman, 2010), which young infants otherwise find challenging (Stager & Werker, 1997). On the other hand, sentence frames are not always sufficient to overcome word learning challenges. For example, when taught a minimal pair embedded in sentence frames, 17-month-olds only showed successful word learning when the speaker's language background (monolingual vs. bilingual) matched their own (Fennell & Byers-Heinlein, 2014).

One unanticipated result was a primacy effect, wherein in Experiments 2 and 3, infants only learned the first of two foreign words that they heard. Although it is possible that this was simply a spurious result, the same effect was found in two separate studies, and thus warrants further discussion. This primacy effect cannot be accounted for by low-level factors as our design was fully counterbalanced with respect to which word-object pairing was presented first during training as well as which word-object pairing was

tested first. Primacy effects have been reported elsewhere in the language acquisition literature, although not for this particular type of study. For example, in study of auditory statistical learning wherein the statistical structure of a nonsense language changed midstream, adults successfully learned the first structure but not the second (Gebhart, Aslin, & Newport, 2009). In another study that attempted to teach 19-month-olds two labels for the same object, infants consistently learned the first label, but only learned the second label when it was requested by the same speaker who taught it, or when it was taught in a different language (Bhagwat & Casasola, 2014). One important difference is that both of these studies used a block design, where participants showed learning of information presented in the first block but not in the second block. Our experiments did not use a block design: the training trials for each of the two words were interspersed pseudo-randomly. Nonetheless, when presented with two foreign words, infants appeared to only learn the foreign word that they encountered on the very first trial.

This finding is in line with recent theoretical frameworks of infant word learning, which suggest that, under difficult word learning situations, infants may prioritize certain information. For example, the PRIMIR framework posits that infants use dynamic filters to direct their attention to some information in the speech stream over other information (Curtin, Byers-Heinlein, & Werker, 2011; Werker & Curtin, 2005). In the current study, infants may have prioritized learning the first foreign word-object pairing they encountered over the second one. Although there were no differences in looking time during training in either Experiment 2 or 3, it is still possible that infants devoted more cognitive resources to extracting and encoding the information related to the first word-object pair, at the expense of the second word-object pair. While the primacy effect

detected in our study was unexpected, it does highlight the challenging nature of learning words in foreign language sentences. More research will be needed to better understand how infants prioritize different information in challenging language-learning situations.

Our results refine and extend several previous findings from the literature on early foreign word learning. While several studies have shown that foreign word forms can challenge young word learners (e.g., MacKenzie et al., 2011; 2012a; May & Werker, 2014), the current research shows that the situation of novel words in foreign sentence frames can pose an additional challenge. This explains why several more naturalistic studies of word learning have had divergent findings, with some showing little difference between native and foreign word learning (Bijeljac-Babic et al., 2009), while others found that only certain subgroups of children were successful (Akhtar et al., 2012; Koenig & Woodward, 2012). It may be that children of different ages and different language backgrounds are differentially sensitive to the foreignness of the word form itself versus its situation within a foreign sentence frame. Future research will be needed to explore this possibility. For example, it would be interesting to directly compare whether foreign word *forms* are best learned when presented in isolation or when presented in foreign sentence frames.

While our study specifically focused on monolingual infants' learning of foreign language words, another interesting direction for future research will be to examine bi- and multilingual infants' foreign word learning. On one hand, bilingual infants need to be flexible word learners to acquire words in both of their languages, and this additional flexibility might support them in foreign word learning. On the other hand, like monolinguals, bilinguals are tuned into the characteristics of their word learning

environments and so might be just as challenged as monolinguals by foreign sentence frames (Fennell & Byers-Heinlein, 2014; Mattock et al., 2010). Bilingual infants' ability to learn foreign language words would need to be tested empirically.

The results from the current study have important implications for foreign language acquisition both inside and outside of the lab. Given that the current set of experiments demonstrates that young word learners are influenced by sentential context, future studies interested in foreign word learning need to control for this when assessing how infants learn foreign word forms. Further, while we know that monolingual infants can and do acquire a second language in naturalistic contexts, findings from the current study highlight that foreign language settings do pose a challenge for young word learners, albeit a challenge that learners seem at least partially capable of overcoming. Such results point towards the importance of informing early childhood educators that while infants are flexible word learners, their word learning is still governed by knowledge and processes that do not make acquiring a second language a trivial activity.

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Figure 1. Example of experimental design and stimuli presented to an English-learning infant.

Figure 2. Mean proportion looking time at target object across experiments, according to language of familiarization (Experiment 1), and when the order the target word was familiarized (Experiments 2 and 3). Error bars represent the standard error of the mean.

* $p < .05$