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Voulez-vous jouer avec moi? Twelve-month-olds understand that foreign languages can communicate

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ABSTRACT

Infants understand that speech in their native language allows speakers to communicate. Is this understanding limited to their native language or does it extend to non-native languages with which infants have no experience? Twelve-month-old infants saw an actor, the Communicator, repeatedly select one of two objects. When the Communicator could no longer reach the target but a Recipient could, the Communicator vocalized a nonsense phrase either in English (infants' native language), Spanish (rhythmically different), or Russian (phonotactically different), or hummed (a non-speech vocalization). Across all three languages, native and non-native, but not humming, infants looked longer when the Recipient gave the Communicator the non-target object. Although, by 12 months, infants do not readily map non-native words to objects or discriminate most non-native speech contrasts, they understand that non-native languages can transfer information to others. Understanding language as a tool for communication extends beyond infants' native language: By 12 months, infants view language as a universal mechanism for transferring and acquiring new information.

1. Introduction

Early perceptual biases draw infants to speech from birth (Butterfield & Siperstein, 1970; Vouloumanos, Hauser, Werker, & Martin, 2010; Vouloumanos & Werker, 2007), and by 6–12 months infants understand an important function of speech: that speech, and not non-speech sounds, can communicate information between people (Martin, Onishi, & Vouloumanos, 2012; Thorgrimsson, Fawcett, & Liszkowski, 2015; Vouloumanos, Martin, & Onishi, 2014; Vouloumanos, Onishi, & Pogue, 2012). Previous studies however only tested communicative understanding using speech sounds consistent with the infants' native language and not non-native languages. But infants' processing of non-native languages changes rapidly: by 12 months, infants no longer map non-native words to objects (e.g., MacKenzie, Curtin, & Graham, 2012), and they no longer discriminate most non-native speech sounds (e.g., Werker & Tees, 1984). Infants' linguistic processing has narrowed to privilege their native language. Even as word learning and speech perception processes favor their native language, infants' understanding of communication might be broader: at 12 months, infants may recognize that non-native languages can transfer information to others. Extending infants' understanding of the communicative function of speech to non-native languages would suggest that infants view language as a universal mechanism for acquiring and transmitting information.

Infants can differentiate between native and non-native languages from birth based on a range of linguistic properties that vary between languages including phonetics, phonotactics, and rhythm (e.g., Bosch & Sebastián-Gallés, 2003; Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993; Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992; Nazzi, Jusczyk, & Johnson, 2000; Werker & Tees, 1984). Rhythm allows even newborn infants to discriminate between stress-timed language, such as English and Russian, which have equal timing between stressed syllables and variable duration between unstressed syllables, and syllable-timed languages, such as Spanish and French, which have roughly equal timing between all syllables (Mehler et al., 1988; Nazzi, Bertoncini, & Mehler, 1998; Nazzi & Ramus, 2003). By 9 months, infants can discriminate between languages within a rhythmic class, such as English and Russian, using phonotactic constraints that specify permissible consonant clusters and vowel sequences within a language (Jusczyk et al., 1993).

As their sensitivity to native speech properties develops, infants' processing of non-native speech properties declines: by 12 months, infants discriminate many non-native phonemes poorly (Bosch & Sebastián-Gallés, 2003; Kuhl et al., 1992; Werker & Tees, 1984), reject word forms with non-native phonotactics as possible labels for objects (MacKenzie et al., 2012), and even disfavor speakers of non-native languages (Kinzler, Dupoux, & Spelke, 2007). Without referential cues, 14–20 month old infants fail to learn words composed of non-native phonemes (May & Werker, 2014) or non-native tonal contrasts (Graf Estes & Hay, 2015; Hay, Graf Estes, Wang, & Saffran, 2015). By

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12 months, infants thus process native and non-native speech and speakers differently. However, infants do not just process speech in terms of its formal linguistic properties, they are also sensitive to its communicative properties. Is infants' understanding of the communicative function of speech limited to their native language, like much of their processing of formal linguistic properties of speech, or does it generalize beyond their specific linguistic experience to a non-native language? We examined whether infants understand that a language that differs rhythmically (Spanish) or phonotactically (Russian) from their native language can communicate information between people.

In the current study, 12-month-old infants watched two actors perform a series of actions (Martin et al., 2012; Vouloumanos et al., 2014). Infants first saw an actor (the Communicator) alone playing with one of two objects, establishing it as the target. Next, a new actor (the Recipient) alone spent equal time playing with both objects. In the test scene, the Communicator and Recipient were present together, but, owing to a change in the setting, the Communicator could no longer reach either object. Instead, she turned to the Recipient and vocalized a nonsense phrase in English, Spanish, Russian, or humming – a non-speech vocalization that may plausibly be communicative but lacks referential specificity and that infants should not infer as transferring information in this situation (see also Martin et al., 2012; Vouloumanos et al., 2012). The Recipient then handed the Communicator either the target object or the non-target object.

If infants understand that non-native languages can communicate, they should look longer at the non-target outcome than at the target outcome in both the Spanish and Russian conditions, as well as in the English condition. The English nonsense phrase, which followed English rhythm and phonotactics, allowed us to examine whether infants recognize that the form of their native language communicates, rather than responding to specific words whose meanings they already knew (e.g., had we used the English phrase equivalents, "give me X" or "I'd like X"). Alternatively, infants might not treat non-native speech as communicative, looking equally at the target and non-target outcomes as they did for non-speech vocalizations in previous studies (Martin et al., 2012; Vouloumanos et al., 2014). A third possibility is that infants may only treat one of the non-native languages as communicative, reflecting a sensitivity to either rhythmic (Spanish) or phonotactic (Russian) properties of language. Finally, we predicted that infants would treat humming as not communicative, similarly to non-speech vocalizations in previous studies, and look equally at target and non-target outcomes.

2. Method

2.1. Participants

Sixty-two healthy, full-term infants (M = 12 months, 11 days (SD = 9 days), range = 11, 23 to 12, 23) participated. This sample size was justified by an a priori power analysis (GPOWER; Faul, Erdfelder, Lang, & Buchner, 2007) indicating that we would need $n = 60$ infants to detect a significant interaction between Vocalization (Speech, Nonspeech) and Outcome (Target, Non-target) in infants' looking times with 80% power at an alpha level of $p < .05$ based on an effect size of $d = 0.37$ (from the interaction between Outcome and Vocalization in Experiment 1 in Martin et al., 2012). Forty-two infants were tested in one of the three Speech conditions. Fourteen infants (6 females) tested in the English condition had a minimum of 50% exposure to English (average exposure to English was 85% (SD = 15%), range: 50–100%). Fourteen infants (5 females) tested in the Spanish condition had 0% exposure to Spanish (average exposure to English was 78% (SD = 30%), range: 15–100%). Fourteen infants (6 females) tested in the Russian condition had 0% exposure to Russian (average exposure to English was 85% (SD = 18%), range: 50–100%). Twenty infants (10 females) were tested in the Nonspeech humming condition.

Data from 35 additional infants were excluded from analysis because of experimenter error (8), parent interference (1), not meeting minimum language criteria (1), pre-existing health conditions (3), never looking away during the entire session (13), fussiness or inattentiveness (8), or looking times greater than 2 standard deviations from the mean (1). The infants who never looked away during the session were evenly distributed across conditions: 8 in the Speech condition: 4 Target, 4 Non-target, and 5 in the Nonspeech humming condition: 3 Target, 2 Non-target. Parents gave informed written consent on behalf of their infants. All procedures were approved by New York University's University Committee on Activities Involving Human Subjects (FY2016-81).

2.2. Apparatus

Infants sat on a parent's lap facing a display at the infant's eye level. Parents closed their eyes after the first familiarization trial. From the infant's viewpoint, the back of the display contained a window, which allowed the Communicator to be visible or not. The right side of the display contained a large opening covered by a yellow curtain, which allowed the Recipient to be visible or not. The left and right sides of the display were covered by two cloth dividers that prevented the infant and parent from seeing beyond the display, while allowing a hidden online coder to see the infant, but not the events on the stage. This online coder recorded whether the infant was looking at the display during each scene by pressing a button on a hand-held controller, which was connected to an iMac computer running Baby (Baillargeon & Barrett, 2005). The infant and the two actors were recorded by video camera.

2.3. Stimuli

Two novel objects were used: a red funnel (10.8 cm tall and 10.2 cm wide at the base), and a rectangular blue plank (13.3 cm tall, 5.1 cm wide, and 1.0 cm thick) that was topped with a blue pipe cleaner loop.

2.4. Procedure

Infants were not familiarized with the non-native languages prior to testing. Each infant saw 5 trials: three familiarization trials, one pretest trial, and one test trial. A beige curtain hid the display between each of the trials. Each trial contained a computer-controlled initial section, during which the actors performed the informative actions, and an infant-controlled main section, during which the actors either remained still or repeated a non-informative action. Reported looking times were recorded during the main section of the test trial after all informative actions had been completed. Trials ended when the infant looked away from the scene for a total of 2 consecutive s after having looked during the main section for 2 s, or if the infant looked for the maximum time. To keep actions and timing consistent across participants, all actors performed their actions in time with a metronome set to one beat per second. The stimuli were positioned so that the infants could see both objects and the two actors could see and reach each object (except as noted). The type and location of the target object were counterbalanced across participants within each vocalization condition. The funnel was the target object for half of the participants, and the plank was the target for the other half. The target object was on the right for half of the participants, and on the left for the other half. During the test trial, half of the participants saw the Recipient present the Communicator with the target object, and the other half saw the Recipient present the Communicator with the non-target object.

2.4.1. Familiarization

When the curtain rose, the Communicator was visible in the window at the back of the display. Only the top of her face and her arms were visible to the infants. The Communicator first looked at a neutral center point of the display (2 s). She then looked at one object (2 s) then the

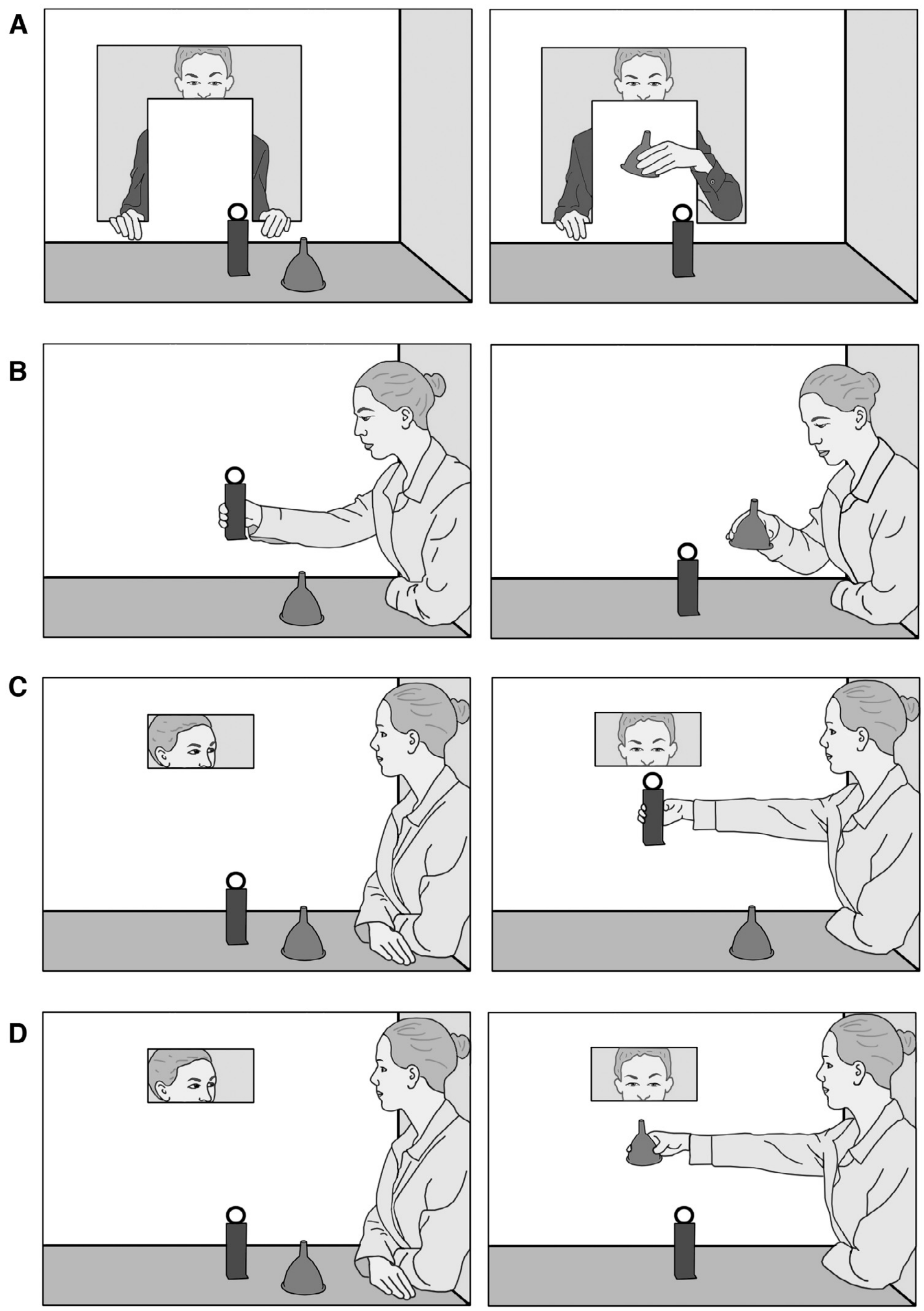

Fig. 1. Method. (A) Familiarization Trial in which the Communicator manipulates a target object. (B) Pretest Trial in which the Recipient manipulates both objects. (C) Test Trial, Target outcome in which the Recipient hands the Communicator the target object. (D) Test Trial, Non-target outcome in which the Recipient hands the Communicator the non-target object. Reprinted from *Cognition, 123*, Martin, Onishi, & Vouloumanos, Understanding the abstract role of speech in communication at 12 months, 50–60, Copyright (2012), with permission from Elsevier.

other object (2 s), looked at and reached for her target object (2 s), lifted the object (1 s) and brought it to a position just below and in front of her chin (1 s). She then tilted the object forward and backward (2 s), ending the initial section. For the remaining main section of the trial, the Communicator looked at the target object as she tilted it back and forth in time with the metronome (18 s). The familiarization trial was presented three times (see Fig. 1A).

2.4.2. Pretest

When the curtain rose, the Recipient was visible on the right side of the display, and the Communicator was no longer present. The Recipient initially looked to a neutral center point on the display (2 s), then at one object (2 s) and at the other object (2 s). She then looked back at the first object (1 s), and reached for, grasped, and lifted it (2 s), tilted it toward and away from herself (2 s), placed the object down, and withdrew her hand (2 s). She then repeated this series of movements on the other object, completing the trial's initial section. For the remaining 15 s of the main section of the trial, the Recipient performed this same series of actions on both objects until the trial was ended. The pretest trial was shown once (see Fig. 1B).

2.4.3. Test

After the curtain rose, both actors were present in the display. However, the window at the back of the display was smaller than in the familiarization trials such that only the top of the Communicator's face was visible and she could no longer reach either object. After the infant looked at the display for at least 2 consecutive s, the Communicator looked at both objects (4 s) then turned and made eye contact with the Recipient and said either "Tiv lee kuh blicket" (English, S1 Audio), "Da me la ñepa" (Spanish = "Give me the X", S2 Audio), or "я хочу вылиздрю" (Ya hatchu vlyzdru; Russian = "I would like X", S3 Audio) (4 s) or hummed the English phrase "Tiv lee kuh blicket" with her mouth closed (Hum, S4 Audio). The vocalization was uttered twice. The Communicator's mouth was not visible to the infants (see Fig. 1C and D) to ensure that the production of the vocalization was visually identical across conditions. Although the word-initial "ñ" in the Spanish nonsense word ñepa violates English phonetics, unlike other more universal phonetic sensitivities, English-learning infants are not sensitive to this contrast at 12 months (Narayan, Werker, & Beddor, 2010). The English nonsense phrase ensured the words were unfamiliar to infants, allowing us to test infants' abstract understanding that speech communicates rather than their understanding of specific words, e.g., a familiar requesting frame "give me the X". The actors who played the Communicator were native speakers of the language they spoke during the test trial. The Recipient then reached for one of the two objects (2 s) and raised it to just below the Communicator's face (2 s) (Fig. 1C and D). This ended the initial section of the test trial. For the remainder of the trial, both actors looked at the raised object until the trial was ended after 40 s or until the infant looked away from the display for 2 s. The infants' looking times were indicated by an online coder who was blind to the specific condition. The trial end was verified by an offline coder using SuperCoder (Hollich, 2008) who was also blind to the condition. Disputes were resolved by a third offline coder.

3. Results

When the Communicator spoke in English, Spanish, or Russian, infants looked longer when the Communicator received the non-target object relative to the target object (see Fig. 2). When the Communicator hummed, infants looked equally at non-target and target trials.

A 2 (outcome: non-target, target) by 2 (vocalization: Speech, Hum) fixed factor analysis of variance (ANOVA) revealed a main effect of outcome, $F(1, 58) = 7.70$, $p = .007$, $f = 0.36$, qualified by an interaction between outcome and vocalization, $F(1, 58) = 4.85$, $p = .032$, $f = 0.29$.

Individual one-way fixed factor ANOVAs confirmed this pattern of results. When the Communicator spoke English, infants looked significantly longer when the Recipient handed over the non-target object ($M = 25.5$ s, $SE = 5.0$) compared to the target object ($M = 12.6$ s, $SE = 3.0$), $F(1, 12) = 4.97$, $p = .046$, $f = 0.52$. When the Communicator spoke Spanish, infants looked longer when the Recipient handed over the non-target object ($M = 25.8$ s, $SE = 3.1$) compared to the target object ($M_t = 13.5$ s, $SE_t = 2.2$), $F(1, 12) = 10.48$, $p = .007$, $f = 0.66$. When the Communicator spoke Russian, infants looked longer when the Recipient handed over the non-target object ($M = 24.6$ s, $SE = 3.9$) compared to the target object ($M = 14.1$ s, $SE = 1.9$), $F(1, 12) = 5.87$, $p = .032$, $f = 0.55$. When the Communicator hummed, infants looked equally when the Recipient handed over the non-target object ($M = 17.7$ s, $SE = 3.8$) and the target object ($M = 16.4$ s, $SE = 2.1$), $F(1, 18) = 0.10$, $p = .76$, $f = 0.07$.

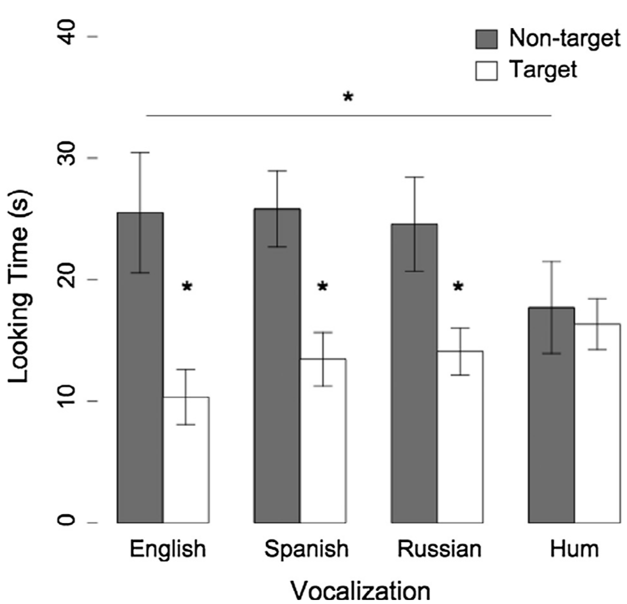

Fig. 2. Results. Mean looking time (in s) ± SEM across infants for each test trial type (Non-target, Target) for each language tested: English, Spanish, Russian, and Humming. An asterisk (*) represents significance at $p < .05$.

To ensure that infant looking times on trials before the test trial did not differ between the different outcome and vocalization conditions, we ran the same 2 (outcome: target, non-target) by 2 (vocalization: Speech, Hum) fixed factor ANOVA on the sum of the looking times in all trials before the test trial and found no effects of outcome or test language on looking time, all $ps > .1$.

To examine the effect of language background on children's performance, and specifically whether exposure to multiple languages was required to infer that non-native languages communicate, we specifically tested whether infants who were only exposed to one language inferred that non-native languages communicate. Of the 28 infants participating in the Spanish and Russian test conditions, 18 were exposed to 90% or more English (and no Spanish or Russian respectively). These infants performed like their multilingual peers, looking longer at the non-target than target outcomes, $M_{\text{non-target}} = 26.2$ s, $SE = 3.34$; $M_{\text{target}} = 11.9$ s, $SE = 1.62$; $F(1, 16) = 16.9$, $p = .001$, $f = 0.65$, suggesting that infants' language background did not affect performance. The sample of infants who heard 100% English participating in the Spanish and Russian conditions was very small (n = 8), but this very conservative sample also showed a looking time difference with a large effect size in the expected direction ($M_{\text{non-target}} = 23.7$ s, $SE = 6.00$; $M_{\text{target}} = 11.4$ s, $SE = 2.69$) which due to the small sample size did not reach statistical significance, $F(1, 6) = 3.53$, $p = .11$, $f = 0.57$.

4. Discussion

We examined whether infants' understanding of the communicative function of speech extends to speech in non-native languages. When the speaker vocalized in Spanish, or Russian – languages that differ from English in rhythm and phonotactics, among other dimensions – infants looked longer when the Recipient handed the Communicator the non-target rather than the target object. Similarly, when the speaker used an English nonsense phrase, infants looked longer when the Recipient handed the Communicator the non-target rather than the target object corroborating results of prior studies in which the Communicator vocalized an isolated English nonsense word (Martin et al., 2012; Vouloumanos et al., 2014). Infants' response to native and non-native speech contrasts with a condition in which the Communicator vocalized using non-speech: when the Communicator hummed, infants looked equally whether the Recipient handed over the target or the non-target object, suggesting they did not infer that humming was communicative. Infants thus infer that non-native languages, like their native language, allow a speaker to communicate about a target object to a recipient. Moreover, there was no effect of infants' own language background on their performance. Although it is possible that exposure to multiple languages facilitates the understanding that non-native language communicate, infants who heard only one language at home performed the same as infants who heard more than one. Infants did not appear to learn about the communicative nature of non-native languages from exposure to multiple languages.

Infants' equal looking for target and non-target outcomes after hearing humming in a potentially communicative interaction can be compared to the looking patterns of infants hearing other non-speech vocalizations in previous studies using this same two-actor communicative interaction. This looking pattern is similar to infants who heard coughing who looked equally at target and non-target outcomes, and different from infants who heard an emotional vocalization who looked longer when the Recipient handed over the target compared to the non-target object (Martin et al., 2012). Like the emotional vocalization, humming could plausibly be interpreted as a communicative attempt – for example, if the speaker's mouth was full – that fails because it lacks the referential specificity to identify the target object. However the difference in looking patterns between humming and emotional vocalizations suggests that infants interpreted them differently. Perhaps the rich prosodic content of the humming vocalization led infants to construe it as musical, and thus not object-directed, an inference that may be a possible precursor for evaluating the communicative function of non-speech vocalizations (e.g., Martin et al., 2012; Woodward, 1998).

Despite clearly treating non-native speech and native speech as distinct – preferring their native language to non-native languages from birth (Mehler et al., 1988) and rejecting non-native word forms as possible object labels at 12 months (MacKenzie et al., 2012) – 12-month-old infants inferred that non-native speech could communicate. Infants correctly infer that non-native speakers are members of a different linguistic community with different conventions who are thus constrained in their label use (Henderson & Scott, 2015; Scott & Henderson, 2013), and they also infer that non-native speakers can transfer information to others using non-native speech. That is, infants recognize that non-native speakers adhere to a different set of naming conventions while still using their language to communicate, just like native speakers do.

Although we have no independent way of confirming that English-hearing infants identified the Spanish and Russian sentences as non-native, based on the types of sounds infants treated as non-native in other studies, we believe the sentences provided enough information to identify them as non-native. Infants heard 5-syllable sentences uttered twice in either Spanish, which was rhythmically distinct from English, or Russian, which contained two non-native phonotactic clusters, "vl" and "zdr", for a total of 10 syllables of each non-native language. Although many studies of non-native language processing use longer stimuli (e.g., Bosch & Sebastián-Gallés, 2003; Jusczyk et al., 1993; Kinzler et al., 2007), infants can treat even single word non-native stimuli differently than native stimuli. For example, at 12 months, English-hearing infants mapped novel single syllable labels to objects when they had native phonology, mapping "plok" but not "ptak" or "svet" (which follow legal Czech phonotactics; MacKenzie et al., 2012). A single illegal phonotactic cluster sufficed for infants to treat these single words differently than nonsense words consistent with their native language phonotactics. In contexts in which they succeed in mapping native words to objects, slightly older infants fail to learn single syllable words with non-native prosody and non-native phonemes: two different Mandarin tones presented as single syllables (Graf Estes & Hay, 2015; Hay et al., 2015), and Khosian clicks presented as single syllables (May & Werker, 2014). Replicating the findings with longer utterances would provide further evidence that infants recognize that non-native languages communicate.

Finding that infants treat non-native languages such as Spanish and Russian as communicative does not necessary mean that they will treat all non-native languages as communicative. Languages that are more dissimilar to their native English language, for example, languages using click consonants such as Bantu or Khoisan languages (e.g., Best, McRoberts, & Sithole, 1988; May & Werker, 2014), or tonal languages such as Mandarin (e.g., Mattock, Molnar, Polka, & Burnham, 2008), would provide interesting extensions.

Infants tested on Spanish or Russian had no prior exposure to these languages, neither in their daily lives, nor in the laboratory before the experiment, suggesting that infants have an abstract understanding of the communicative nature of speech that extends beyond the language (s) to which they have been exposed. One possibility is that infants generalize the communicative nature of their native language to these new non-native languages. The current study does not address whether experience with a native language and its use in communicative contexts forms the basis for a more generalized understanding of the communicative function of non-native speech (as in processes discussed in e.g., Fisher, 2002; Mandler, 2000; Waxman, 2002). An alternative possibility is that experience with the native language is not an essential precursor to understanding that speech *qua* speech is communicative: simply watching individuals respond contingently in a social context might provide a basis for inferring the transfer of information (e.g., Beier & Carey, 2014). Further work is required to choose between these possibilities.

The scope of acquired knowledge – narrow or broad, concrete or abstract – is a fundamental debate in language acquisition and conceptual development (e.g., Mandler, 2000). Is children's word learning item based (Smith, 2000; Tomasello & Abbot-Smith, 2002), or generalizable to a semantic class (Fisher, 2002) or category (Waxman, 2002)? Does infants' hesitation at the top of a cliff reflect a generalized fear of heights (Campos, Bertenthal, & Kermoian, 1992) or posture-specific avoidance (Kretch & Adolph, 2013)? Generalising knowledge beyond initial exposure would allow organisms to navigate new environments adaptively using their already acquired knowledge. The current findings suggest that infants' abstract understanding of the communicative nature of speech extends beyond their specific language experience allowing them to recognize that foreign languages can communicate. By 12 months, infants view language as a universal machanism for transferring and acquiring new information.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.cognition.2018.01.002.

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