



Can a Click be a Word?: Infants' Learning of Non-Native Words

Lillian May and Janet F. Werker

Department of Psychology

The University of British Columbia

Forms that are nonlinguistic markers in one language (i.e., “tsk-tsk” in English) may be part of the phoneme inventory—and hence part of words—in another language. In the current paper, we demonstrate that infants' ability to learn words containing unfamiliar language sounds is influenced by the age and vocabulary size of the infant learner, as well as by cues to the speaker's referential intent. When referential cues were available, infants at 14 months learned words with non-native speech sounds, but at 20 months only those infants with smaller vocabularies succeeded. When no referential cues were present, infants at both 14 and 20 months failed to learn the same words. The implications of the relation between linguistic sophistication and non-native word learning are discussed.

INTRODUCTION

Growing up in our multilingual world, virtually all children are at some point exposed to a language different from that they have learned since birth. Children may relocate to new countries and linguistic environments, may enter schools or daycares in which a new language is spoken or learn a second language to communicate with family and friends. One of the

Correspondence should be sent to Lillian May, Department of Psychology, University of British Columbia, 2136 West Mall, Vancouver, British Columbia V6T 1Z4, Canada. E-mail: lamay@psych.ubc.ca

critical difficulties in learning a new language is that different languages use different inventories of consonant and vowel sounds to form meaningful speech (Maddieson, 2011). In the present research, we examine the development of how infants approach learning words that contain unfamiliar language sounds very distinct from those used in their native language.

Infants begin to tune to the specific properties of their native language by their first days of life. At birth, neonates prefer to listen to the language they experienced *in utero* versus rhythmically different languages and show differential brain responses to familiar and unfamiliar languages (Byers-Heinlein, Burns, & Werker, 2010; May, Byers-Heinlein, Gervain, & Werker, 2011; Mehler et al., 1988; Sato et al., 2011). Between 6 and 12 months of age, infants shift from discriminating native and non-native speech sound contrasts equally well, to discriminating best (and in some cases, only) the speech sounds that are used to contrast meaning in their language (Kuhl et al., 2008; Saffran, Werker, & Werner, 2006; Werker & Tees, 1984). Further, by 9 months of age, infants prefer to listen to words that conform to the stress pattern and phonotactics (acceptable sequences of sounds) used in their language (Johnson & Jusczyk, 2001; Jusczyk, Cutler, & Redanz, 1993; Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993). This body of research illustrates that a growing attunement to the sounds and sound patterns of the native language is established by the end of the first year of life, around the time infants begin more rapidly mapping novel words to concepts (Schafer & Plunkett, 2008; Woodward, Markman, & Fitzsimmons, 1994).

While infants' early sensitivity to the speech sound inventory of their native language may be advantageous in directing them toward word-forms most likely to serve as labels in their own language, a strict adherence to only the most familiar forms could lead to difficulty learning a new language. This difficulty would be mitigated, however, if infants could use cues other than, or in addition to, the sounds of an unfamiliar-sounding word to determine whether it constitutes a possible label. Indeed, in many situations in which infants hear a potential new label, there are referential and/or social indications that the heard label is intended to refer to a seen object or concept even when the sounds of the word are unfamiliar: For example, a speaker may point to a target object during labeling or use the new word in a familiar labeling context (Baldwin, 1993, 1995; Baldwin, Markman, Bill, Desjardins, & Irwin, 1996; Fennell & Waxman, 2010). It may be that such referential and/or social cues facilitate infants' learning of unfamiliar words comprised of sounds not used in the native language. Moreover, as development progresses and infants become more advanced word-learners, the strength of word-form and/or social and

referential cues may change. In the current studies, we examine these possibilities, investigating how infants' success in mapping non-native word-forms to objects varies as a function of infant age, vocabulary size, and the presence of referential indicators.

What is a word?

Previous research exploring infants' learning of linguistic versus nonlanguage labels as object names has suggested that the range of forms infants accept as labels changes across development. When provided with cues to a word-form's intended reference, infants aged 12–18 months learn nonlanguage symbols such as toy noises, gestures, and pictograms as labels in the same manner in which they learn novel native language labels (Campbell & Namy, 2003; Hollich et al., 2000; Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999). Yet at 20–26 months of age, infants appear to be more selective, learning only linguistic and not nonlanguage labels even when the same supporting referential and social indications are present (Namy & Waxman, 1998; Woodward & Hoyne, 1999).

In the present research, we ask whether the same developmental trend also guides infants' learning of unfamiliar-sounding non-native labels. We test 14- and 20-month-old English-learning infants' learning of words containing click sounds (described in detail below), which are used linguistically in some languages, but differ significantly from the speech sounds of English. Indeed, click sounds fall so far outside of English phonology that they are not subject to the “perceptual narrowing” seen in the first year of life for infants' discrimination of non-native speech sound contrasts (Best, McRoberts, & Sithole, 1988; Best, 1994; see also Best & Avery, 1999).

Previous studies examining infants' learning of non-native labels have offered what may appear to be outwardly contradictory results. In studies using associative word-learning tasks, infants aged 12–18 months have been found to have difficulty learning non-native words that are phonotactically illegal in the infants' native language (Graf-Estes, Edwards, & Saffran, 2011; MacKenzie, Curtin, & Graham, 2012). In contrast, Bijeljac-Babic, Nassurally, Havy, and Nazi (2009) found that 20-month-old French infants successfully learned labels in both native French (embedded in French carrier phrases) and in non-native English (in English carrier phrases). Two key differences between these studies may serve to illuminate key factors that influence infants' learning of non-native labels. First, the labels used by MacKenzie et al. (2012) and Graf-Estes et al. (2011) were not only non-native, but were also phonotactically illegal in the infants' native language—meaning that the sound patterns were likely quite distinct and unfamiliar to the infant. In contrast, the non-native

labels used by Bijeljac-Babic et al. (2009) were pseudowords produced in a foreign language, but were not phonotactically illegal in the infants' native language. This difference in phonotactic legality may have contributed to infants' success in the Bijeljac-Babic et al. (2009) study versus the lack of success in learning the phonotactically illegal labels in MacKenzie et al. (2012) and Graf-Estes et al. (2011) studies. Secondly, these studies differed in the degree of cues available to the infant indicating the non-native label's intended reference. MacKenzie et al. (2012) and Graf-Estes et al. (2011) presented with objects in passive associative learning paradigms, with few explicit cues to reference. However, Bijeljac-Babic et al. (2009) presented infants with the foreign words in sentence frames (albeit spoken in a foreign language), provided practice trials to familiarize the infants with the structure of the task, and used a task that itself was richly interactive. All of these factors serve to create a more intentional, referential context, which may have additionally contributed to infants' success in learning the non-native labels in this study.

Evidence from a related literature examining infants' abilities to learn novel native language labels that differ in only a single consonant or vowel sound (minimal pair labels) has confirmed that referential cues significantly improve young learners' performance. In the same type of associative word-learning task employed by MacKenzie et al. (2012), infants consistently learned phonetically dissimilar words (such as "lif" and "neem") starting at 12–14 months, but until 18 months of age failed to reliably learn minimal pairs labels (such as "bin" and "din") (Pater, Stager, & Werker, 2004; Stager & Werker, 1997; Werker, Fennell, Corcoran, & Stager, 2002). However, if referential cues were added, infants succeeded in learning minimal pair labels even at 14 months (Fennell & Waxman, 2010; see also Fais et al., 2012). In their study, Fennell and Waxman (2010) showed that presenting words in sentence frames rather than in isolation ("look at the bin" versus "bin") enabled 14-month-olds to succeed. Moreover, 14-month-old infants also succeeded if they were first presented with known word–object pairings (such as the word "dog" and a picture of a dog) prior to being trained on the novel minimal pair word–object pairings. Fennell and Waxman argue that these "training" trials provided additional information to infants still inexpert at pairing sound to meaning: In seeing known objects paired with their known labels, a referential context was created in which novel labels may also be more likely to be perceived as intended to refer to the target object.

In the present research, we ask whether referential cues also facilitate infants' learning of non-native words comprised of unfamiliar sounds. Additionally, we explore whether referential cues are equally persuasive

for infants of different ages/developmental levels. As described above, when infants' learning of nonlanguage labels has been explored, younger word-learners (12–18 months of age) successfully map a wide range of symbols including toy noises, gestures, and pictograms to objects in word-learning tasks containing referential cues (Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999). However, older word-learners (20–26 months) no longer map nonlinguistic symbols to objects, even in the presence of referential indicators (Namy & Waxman, 1998; Woodward & Hoyne, 1999). Thus, it may be that as infants become more familiar with the sounds and structures of words used in their native language, referential cues are less effective in facilitating learning of atypical and unusual-sounding word-forms.

The word-forms employed in the current studies were non-native labels containing click consonants. Click consonants are a class of sounds used in many language families, primarily in Southern Africa (such as the Khoisan and Bantu families). In the Khoisan family of languages, from which the labels used in our studies were taken, clicks make up an important part of the phonological sound inventory: For example, Traill (1994) reported that over 70% of the words in the dictionary of !Xóo (a Khoisan language spoken in Botswana and Namibia) begin with a click consonant. While used extensively in many languages, click consonants are not used linguistically in English and are very dissimilar in both perception and production from English language speech sounds. Indeed, English-speaking adults often fail to recognize click consonants as language sounds, instead reporting the sounds in nonlinguistic terms such as “plops” or “finger snaps” (Best et al., 1988), and click sounds do not activate classic language-processing areas in the brains of English-speaking adults—although they do in the brains of click speakers (Best & Avery, 1999).

By 10–12 months of age, English-learning infants also show differences in their perception of click consonants versus non-native sounds more similar to those used in English. While English-learning infants over 10–12 months of age have difficulty discriminating many unfamiliar minimally contrastive non-native speech sounds not used to contrast meaning in their native language (such as the Hindi dental-retroflex contrast, Werker & Tees, 1984), infants 6–8 as well as 10–12 months successfully distinguish equally foreign minimally contrastive click consonants (as do English-speaking adults; Best & McRoberts, 2003). It has been proposed that because click consonants are so distinct from any English language speech sound, these sounds may be perceived as nonlinguistic—leading to the observed differences in discrimination (Best, McRoberts, & Goodell, 2001; Best et al., 1988).

Click labels therefore present a case of non-native words that English-learning infants may have particular difficulty recognizing as potential language forms. In the current studies, we sought to examine whether and how infants' learning of these unfamiliar-sounding forms differs across development and in different word-learning tasks. Specifically, we conducted two experiments with infants aged 14 and 20 months: Experiment 1 tested infants' learning of non-native labels in a word-object association learning task that included additional contextual cues to the labels' reference, while in Experiment 2 these cues were removed. Additionally, to explore whether any differences seen across the two age groups may be better explained by vocabulary size, we compared success in mapping the non-native words to objects between infants with comparatively large and small vocabularies at each age.

EXPERIMENT 1

In Experiment 1, we used a modified version of the referential Switch procedure developed by Fennell and Waxman (2010) to test whether infants successfully learn novel word-forms containing unfamiliar non-native click sounds as object labels. The Switch procedure, designed by Werker, Cohen, Lloyd, Casasola, and Stager (1998), has been used extensively to explore infants' abilities to map novel words to novel objects at 12–22 months of age (e.g., Fennell, Byers-Heinlein, & Werker, 2007; Graf-Estes, Evans, Alibali, & Saffran, 2007; MacKenzie, Graham, & Curtin, 2010; Thiessen, 2007; Werker et al., 2002). In this task, infants are habituated to two novel word-object associations and then tested on whether a violation of the pairings (wherein a familiar object and familiar word from habituation are presented in a novel pairing) is detected. If an infant has learned the association between words and objects, they should look longer during a test trial containing a novel pairing (called the “Switch” trial), than when tested with a familiar pairing (called the “Same” trial) while no such difference is expected if the infant has not learned the word-object pairings.

Given the success of Bijeljac-Babic et al. (2009) in teaching infants non-native labels in an explicitly referential word-learning paradigm, we used a “referential” version of the Switch task (Fennell & Waxman, 2010). The overall two-object “Switch” design is maintained, but there is an added training phase, during which infants first see familiar objects paired with their conventional labels, also likely to be known to the infants (e.g., infants see an image of a dog and hear “dog”). This training phase is thought to provide contextual cues to the infants that the words heard *refer* to the object being shown.

Given previous evidence demonstrating a developmental pattern in infants' learning of language versus nonlinguistic labels during the second year of life, we examined non-native word-learning in both 14- and 20-month-olds, the same ages tested by Woodward and Hoyne (1999). As outlined above, we hypothesized that referential cues would impact younger word-learning infants' performance, but not older infants' performance, when learning unfamiliar-sounding non-native labels. As such, we predicted that in the referential Switch procedure when cues to a potential labels' reference were present, 14-month-old infants would successfully learn non-native words containing unfamiliar sounds (indicated by longer looking to "Switch" over "Same trials). Furthermore, we predicted that cues to a label's intended reference may be less influential for older infants more familiar with the sound structure of their native language and thus that 20-month-old infants would fail to learn the non-native words even in the presence of referential cues. According to these predictions, infants' learning of the unfamiliar non-native words would follow a similar developmental pattern to that which has previously been observed for the learning of nonlanguage labels, even when taught in social and referential word-learning tasks (Namy & Waxman, 1998; Woodward & Hoyne, 1999).

METHOD

Participants

Forty-eight full-term infants were tested in Experiment 1 (25 male, 23 female): 24 14-month-olds ($M = 14$ months, 1.12 days, range: 13 months, 11 days to 14 months, 22 days), and 24 20-month-olds ($M = 19$ months, 27.14 days, range: 19 months, 16 days to 20 months, 14 days). Infants were recruited by contact with new parents at the local maternity hospital and by community flyers and referrals. Infants were contacted for the study through the University of British Columbia Early Development Research Group database. All infants came from English-speaking homes, and parents indicated that infants were hearing English at least 80% of the time. Thirty-six additional infants were tested but excluded from the analyses: 22 due to fussiness, seven due to the parent stopping the study early, one due to experimenter error, two due to the parent reporting the child having an ear infection at the time of test, three due to the infant not looking at least 1 sec during each test trial, and 1 due to the infant failing to habituate (defined as looking the maximum 20 sec at the last habituation trial and in both test trials).

Stimuli

The referential training stimuli consisted of labels that named familiar objects shown on the screen: “kitty,” “dog,” “baby,” and “car.” As it was impossible to use the same speaker for both the referential training tokens and the click stimuli, we chose to record referential training tokens being spoken by two different speakers, with the aim of encouraging generalization to the click stimuli.

Visual stimuli used for habituation and test were two brightly colored objects presented in isolation, identical to those used in previous work (Werker, Byers-Heinlein, & Fennell, 2009; Werker et al., 1998). Objects were presented against a black background. Auditory stimuli used for habituation and test were two CV words, [!a] and [!|u], from the Khoisan language N|uu. N|uu is an endangered language spoken in the Northern Cape Province of South Africa and is part of the Tuu language family. N|uu was chosen for the present study because its phonological inventory has recently been documented and recorded by Miller et al. (2009). The click words used in the present study were actual N|uu words, [!a] meaning “hartebeest,” and [!|u] meaning “grasshopper.” The click sounds in these two words are acoustically distinct ([! is a postalveolar click, and [!| is a lateral-alveolar click), as were the vowels ([a is an open front vowel, and [u is a closed back vowel). Therefore, the two click words do not sound similar, even to adult English speakers.

The N|uu stimuli were recorded by Ouma Katrina Esau, a female native speaker of N|uu, for Miller et al. (2009). In the recordings, the speaker uttered the phrase (in N|uu) “Now I say . . .X.” The target word “X” was then extracted from the recorded sentence and presented to the infant in isolation. This provided natural language prosody on the isolated word, while also reducing potential coarticulatory cues. Four tokens of each word were used. The pre/posttest stimulus was the novel English pseudoword “ghee” ([gi]), recorded by an English speaker.

Procedure

Infants were tested in a dimly-lit, sound-attenuated room. They were seated on a parent or caregiver’s lap, approximately 46 inches in front of a 42-inch plasma television screen onto which visual stimuli were projected. Auditory stimuli were relayed to a NAD Electronics 3020E Stereo Amplifier and played at approximately 65 dB, through two Bose 101 Music Motion speakers situated on either side of the television monitor and hidden from view by a black curtain. To avoid parental interference or influence during the study, parents wore headphones and listened to

music during the task. The experimenter controlled the study by using a computer running the Habit 2002 program (Cohen, Atkinson, & Chaput, 2002) in a remote room and recorded infants' looking time onto either a Canon ZR950 digital video camera or an Apple computer. While controlling the task, the experimenter was blind to trial type.

Each trial was 20 sec long and began when the infant fixated on an onscreen attention-getter. During the trial, the visual object moved continuously across the screen in a horizontal direction, and the auditory stimulus was played a total of 13 times per trial with approximately 1 sec in between each stimulus presentation. Audio and visual presentations of the stimuli were intentionally asynchronous, as per previous research (Werker et al., 1998).

The referential training phase occurred at the start of the study, in which infants were presented with four referential training trials containing the familiar objects and labels. Two orders of referential training trials were counterbalanced across participants. Infants were then presented with a pretest video of a waterwheel, accompanied by the sound "ghee." After the pretest trial, the habituation phase began, during which counterbalanced blocks of four habituation trials (each block containing two tokens of each type) were presented until infant looking time to a block of four trials decreased to less than 50% of the infants' longest looking time to a block or until 24 trials were presented, whichever occurred first. Following the habituation trials, two test trials occurred: a "Same" trial and a "Switch" trial. In the Same trial, a familiar object-label pairing from the habituation phase was presented. In the Switch trial, a familiar visual stimulus and a familiar auditory stimulus were presented, but in a new combination (e.g., Object A with Label B). Eight test orders were counterbalanced across infants. For half the infants, the visual object was the same in both test trials, and for half the infants, the auditory stimuli were the same in both test trials. Finally, infants were presented with a posttest trial identical to the pretest.

After completing the word-learning task, parents or caregivers filled out the MacArthur-Bates Short-Form Vocabulary Checklist (Fenson et al., 2000). Parents of 14-month-olds filled out the Level I form (developed and normed for infants under 18 months of age), while parents of 20-month-olds filled out the Level IIB form (developed and normed for infants over 18 months of age).

RESULTS

Infant looking time was coded offline, frame-by-frame (29.97 frames per second), by an experienced coder who was blind to condition assignment.

For each infant, total looking time to the pretest and posttest trials, the first and last habituation trials, and the two test trials were calculated. A random selection of 20% of the infants was additionally coded by a second blind coder for reliability purposes, and all trials were coded to within 1-sec agreement. To assess the role of vocabulary, infants at both ages were divided into low and high vocabulary groups using the median scores on the MacArthur short-form Communicative Development Inventories (CDI). In the 14-month-old group, 13 infants were assigned as low vocabulary and 11 as high vocabulary based upon comprehension vocabulary ($Med = 28$). Comprehension vocabulary scores were used as at this age several parents reported their child to not be producing any words on the checklist at 14 months. At 20 months, 12 infants were assigned as low vocabulary and 12 as high vocabulary based upon productive vocabulary ($Med = 26$). Here, productive vocabulary scores were used, as no comprehension vocabulary measure is included on the CDI (on either the short form or the longer form) at this age.

Data were analyzed in three repeated measures ANOVAs exploring the effects of infant age (14 versus 20 months), vocabulary group (low versus high), and looking time to three contrasts of interest: (1) pre- versus posttest trials, (2) first habituation versus last habituation trials, and (3) Same versus Switch test trials. The analysis of primary interest was the comparison between Same and Switch test trials: If infants are able to map the click words to objects during the habituation phrase, their looking time during test should be greater to the Switch trial than to the Same trial.

There were no differences in looking to the pretest ($M = 19.18s$, $SD = 1.77$) versus posttest trials ($M = 18.41s$, $SD = 2.95$), $F(1, 44) = 2.30$, $p > .10$, confirming that infants did remain engaged in the task throughout the testing procedure. Infants looked significantly longer to the first habituation trials ($M = 15.64$, $SD = 3.56$) than to the last habituation trials ($M = 8.12$, $SD = 4.95$), $F(1, 44) = 100.98$, $\eta^2 = .70$, $p < .001$, confirming that they did habituate during the procedure. The number of habituation trials ranged from 8 to 24, with a mean of 16.17 trials ($SD = 5.95$). No interactions for infant age or vocabulary group were found for looking time to pre- versus posttest trials (age: $F(1, 44) = .41$, $p > .20$), vocabulary group: $F(1, 44) = .41$, $p > .20$), looking time to first versus last habituation trials (age: $F(1, 44) = .60$, $p > .20$, vocabulary group: $F(1, 44) = 2.57$, $p > .10$), or number of habituation trials (Age: $t(46) = -.09$, $p > .20$), vocabulary group: $t(46) = -.44$, $p > .20$).

An overall main effect of looking to Same versus Switch trials was observed, where infants looked longer to the Switch trial ($M = 10.30s$, $SD = 5.37$) than to the Same trial ($M = 8.56$, $SD = 4.23$), $F(1, 44) = 8.97$, $\eta^2 = .17$, $p < .01$. Additionally, a three-way interaction was found

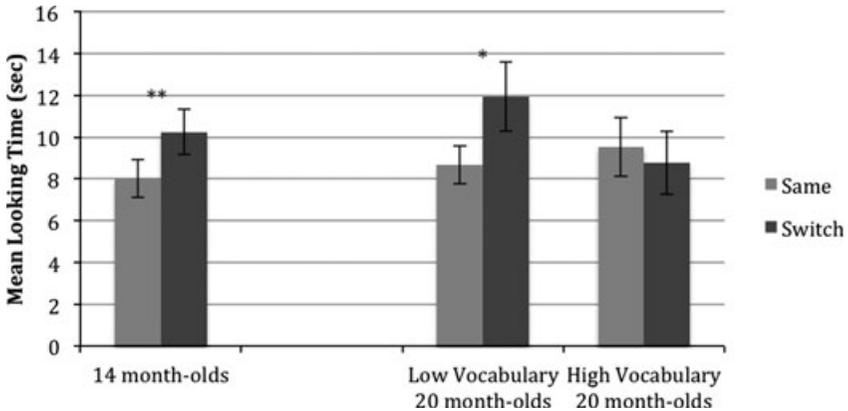


Figure 1 Mean looking time to Same versus Switch test trials, Experiment 1 (referential word-learning task). Fourteen-month-old infants and 20-month-old infants with low vocabularies looked significantly longer to the Switch versus Same test trial. Error bars represent standard error. * $p < .05$, ** $p < .01$.

between infant age, vocabulary group, and looking to Same versus Switch test trials, $F(1, 44) = 5.25$, $\eta p^2 = .11$, $p < .05$ (Figure 1). Follow-up analyses revealed an overall effect of test trial at 14 months: Infants looked longer to the Switch trial ($M = 10.24s$, $SD = 5.22$) than to the Same trial ($M = 8.03s$, $SD = 4.47$), $F(1, 22) = 10.67$, $\eta p^2 = .58$, $p < .01$. No interaction with vocabulary group was seen at this age, $F(1, 22) = .979$, $p > .20$. In contrast, in the 20-month age group, we observed a significant interaction between vocabulary group and test trial, $F(1, 22) = 4.48$, $\eta p^2 = .21$, $p < .05$. Follow-up analyses indicated that while 20-month-olds in the low vocabulary group looked significantly longer to the Switch trial ($M = 11.95s$, $SD = 5.76$) than to the Same trial ($M = 8.66s$, $SD = 3.14$), $t(11) = 2.366$, $\eta p^2 = .34$, $p = .037$, no significant difference was present in looking to the Switch ($M = 8.76$, $SD = 5.25$) versus Same ($M = 9.52s$, $SD = 4.83$) trials for 20-month-olds in the high vocabulary group, $F(1, 11) = .33$, $p > .20$.

DISCUSSION

The results from Experiment 1 show that 14-month-old infants succeed in mapping non-native, unfamiliar-sounding click words to objects in the referential Switch task. At this age, success was seen irrespective of vocabulary size. In contrast, at 20 months, there was an interaction between vocabulary size and looking time to Same versus Switch trial.

Twenty-month-old infants with smaller vocabularies looked longer to the Switch trial than to the Same trial, indicating success in linking the click words with objects, while the 20-month-old infants with larger vocabularies showed no such success. These findings are consistent with past research showing that infants aged 12–18 months, but not 20–26 months, learn a wide range of symbols as object labels when provided with referential cues (Hollich et al., 2000; Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999).

In previous work, 20-month-old infants have been shown to successfully map native language words of similar CV structure (“bih” and “dih”) to objects in the more difficult, nonreferential associative Switch task (Werker et al., 2002). Therefore, it is unlikely that the failure of the high vocabulary 20-month-olds in the current study is due to boredom or lack of interest in the task. Additionally, past studies have shown that English-learning infants as well as adults are able to discriminate between non-native click consonants (Best & McRoberts, 2003), suggesting that the 20-month-olds’ lack of differential looking to test trials was not driven by a difficulty in telling apart the click words. Moreover, the click words we used were not minimal pairs and are quite distinct acoustically and phonetically. We thus argue that the failure of 20-month-old infants with high vocabularies in Experiment 1 is due to the unfamiliar nature of the non-native click labels.

Still not fully addressed by Experiment 1 is the role of referential intent in non-native word learning. While our findings reveal a developmental change between 14-month-olds (and low vocabulary 20-month-olds) and high vocabulary 20-month-olds in infants’ learning of unfamiliar-sounding non-native words when referential cues are present, these results do not address what role referential cues play in this shift. As we point out in the introduction, it may be that referential cues are essential for younger word-learners to treat unfamiliar-sounding words as potential labels. Alternatively, it is possible that the developmental shift observed in Experiment 1 is driven entirely by age and vocabulary size and that referential cues play no role. In Experiment 2 we directly tested these possibilities and compared 14- and 20-month-old infants’ learning of non-native click words in a task matched to that used in Experiment 1, but with no referential cues present.

EXPERIMENT 2

In Experiment 2, we employed the classic “Switch” procedure to test 14- and 20-month-old infants’ learning of non-native click words in the

absence of overt referential cues. Unlike in Experiment 1, infants were not first prefamiliarized with referential training trials showing familiar object–familiar label pairings. If referential cues are necessary to enable less linguistically advanced infants (14-month-olds and 20-month-olds with smaller vocabularies) to succeed at mapping non-native, unfamiliar-sounding word-forms to objects, then without a referential context infants at both ages should fail in the associative word-learning task. On the contrary, if the difference in performance between the 14- and 20-month-olds seen in Experiment 1 is due to age and vocabulary size only, then the same pattern of results should be seen in Experiment 2: success at 14 months and in low vocabulary infants at 20 months, but not in high vocabulary infants at 20 months.

METHOD

Participants

Forty-eight full-term infants were tested (24 male, 24 female): 24 14-month-olds ($M = 14$ months, 2.16 days Range = 13 months, 15 days to 14 months, 22 days) and 24 20-month-olds ($M = 19$ months, 26.79 days, range = 19 months, 13 days to 20 months, 18 days). Infants were recruited in the same manner as Experiment 1 and fit the same language criteria (>80% English exposure). Forty-five additional infants were tested but excluded from the analyses: 31 due to fussiness, 1 due to experimenter error, 9 due to parental interference, and 4 due to insufficient looking at test (minimum of 1 sec during each test trial).

Stimuli and procedure

The stimuli and word-learning procedure were identical to those used in Experiment 1, except that no training trials were shown. Instead, infants immediately saw the pretest trial (waterwheel video with nonsense word “ghee”), followed by habituation trials. As in Experiment 1, after infants participated in the word-learning task, parents/caregivers completed either the Level I (14 months) or Level II-A (20 months) form of the MacArthur–Bates Short-Form Vocabulary Checklist (Fenson et al., 2000).

RESULTS

Data were analyzed in the same manner as Experiment 1. In the 14-month-old group, 12 infants were assigned to the low vocabulary group

and 12 to the high vocabulary group (Med = 26.5, comprehension vocabulary). Similarly, 12 infants were assigned to the low vocabulary group and 12 to the high vocabulary group in the 20-month-old sample (Med = 20.5, productive vocabulary).

As in Experiment 1, infants in Experiment 2 showed no difference in looking to the pretest ($M = 18.97s$, $SD = 1.67$) versus posttest trial ($M = 19.02s$, $SD = 2.21$), $F(1, 44) = .02$, $p > .20$ and looked significantly longer to the first habituation trial ($M = 16.98s$, $SD = 2.76$) than to the last habituation trial ($M = 9.92s$, $SD = 4.13$), $F(1, 44) = 117.27$, $\eta p^2 = .73$, $p < .001$, confirming that infants did habituate during the procedure. The number of habituation trials ranged from 8 to 24, with a mean of 19 trials ($SD = 5.81$). No interactions for infant age or vocabulary group were found for looking time to pre- versus posttest trials (age: $F(1, 44) = .64$, $p > .20$), vocabulary group: $F(1, 44) = 3.03$, $p > .05$), looking time to first versus last habituation trials (age: $F(1, 44) = 2.01$, $p > .10$), vocabulary group: $F(1, 44) = .55$, $p > .20$), or number of habituation trials (age: $t(46) = .20$, $p > .20$), vocabulary group: $t(46) = 1.41$, $p > .0$).

The primary analysis of interest was to compare infant looking time to the Same and Switch test trials across infant age and vocabulary group. A three-way repeated measures ANOVA showed no significant main effects or interactions (test trial: $F(1, 44) = .01$, $p > .20$, Test trial \times Age: $F(1, 44) = .05$, $p > .02$, Test trial \times Vocabulary Group: $F(1, 44) = 1.38$,

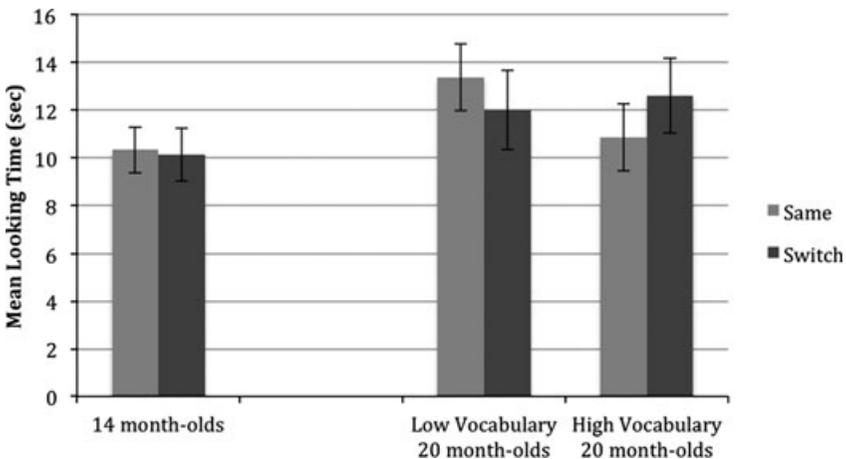


Figure 2 Mean looking time to Same versus Switch test trials, Experiment 2 (associative word-learning task). No effects of looking time to Same versus Switch trials were found. Error bars represent standard error.

$p > .20$; Test Trial \times Age \times Vocabulary Group: $F(1, 44) = .36$, $p > .20$), revealing that infants at both ages and in both vocabulary groups did not look significantly longer to the Switch trial than to the Same trial (Figure 2).

DISCUSSION

Results from Experiment 2 reveal no evidence that in an associative word-learning task either 14- or 20-month-old infants map non-native click words containing unfamiliar click consonants to objects. This failure is unlikely to be driven solely by the lack of referential cues in the word-learning task, as infants of both ages have repeatedly been shown to map dissimilar-sounding native language pseudowords to objects in previous studies using the same procedure (MacKenzie et al., 2010; Werker et al., 1998, 2002). Instead, our findings suggest that the unfamiliar, non-native nature of the click words contributed to infants' lack of success in mapping these labels to objects.

Given that the click sounds in these words fall far from the phoneme inventory of English, we hypothesize that it is likely difficult for young word-learning infants to recognize these unusual word-forms as potential labels when there is little information provided that the click words are intended to serve as labels for the novel objects. These findings build upon previous work showing the important role referential and social cues play in early word learning (Baldwin, 1993, 1995; Campbell & Namy, 2003; Fennell & Waxman, 2010). Furthermore, our evidence suggests that referential cues may be particularly important in difficult word-learning situations, such as with the unfamiliar-sounding non-native labels used in the current study.

GENERAL DISCUSSION

Each language has its own conventions regarding the sounds and structures of words: The word-form in English for the protective covering worn on feet is the sound "shoe"; in Polish, it is the sound "trzewik", and in American Sign Language, it is the motion of two closed hands gently struck together twice. While each of these word-forms is appropriate in its own language, it would not necessarily be an appropriate form in another language.

In the present research, we examined how age and vocabulary size interact with infants' learning of non-native labels. Fourteen- and 20-month-old English-learning infants were tested on their ability to map words containing unfamiliar non-native click consonants to objects in

both referential (Experiment 1) and nonreferential (Experiment 2) associative word-learning tasks. Across the two experiments, we found that infants at 14 months of age successfully mapped non-native click words to objects, but only when cues to referential intent were provided. Without cues to referential intent, infants of 14 months did not show evidence of mapping non-native click words to objects. Similarly, at 20 months of age, cues to referential intent were found to facilitate learning the click word labels in infants with smaller vocabulary sizes. In contrast, 20-month-old infants with larger vocabulary sizes showed no success in mapping the unfamiliar-sounding non-native words to objects, either in the presence or absence of referential cues. We argue that these findings indicate that younger word-learners rely more heavily on cues to reference in determining what forms constitute potential labels than do older infants with more established vocabularies (see also MacKenzie, Graham, Curtin, & Archer, 2014, for further discussion on the role of reference in learning unusual-sounding or atypical labels). In older infants, the rules or regularities of the sound structure of words in the native language appear to play a greater role in constraining word learning.

Although we observed that vocabulary size was related to success in mapping non-native click words to objects at 20 months when referential cues were available, we found no effect of vocabulary at 14 months. Due to different versions of the vocabulary checklist normed for administration at each age, we cannot directly compare vocabulary size at 14 and 20 months. However, it is likely that even the most advanced 14-month-olds had smaller vocabularies than the 20-month-olds. As such, it could be that infants' difficulty or unwillingness to pair non-native word-forms with objects develops only once a sufficiently sizeable lexicon is acquired. Or infants could need to amass *both* the lexical size as well as attain a certain level of familiarity with the word-forms of their language before they are selective about the phonological structure of novel forms when learning new labels.

Alternatively, it is possible that it is the establishment of a more abstract linguistic system that enables older infants with larger vocabularies to attend more to the sounds of potential words. As has been argued previously, perhaps by later in infancy, vocabulary size interacts with additional developmental achievements to allow infants to have a more abstract representation of the phonological structure of their language (as in PRIMIR, Werker & Curtin, 2005; Curtin & Werker, 2007; see also Swingley, 2009; Nazzi & Bertoncini, 2003, for related frameworks). Such abstract representations have been argued to guide, rather than just co-occur with, word-learning and as such could allow infants to be led by their knowledge of what a possible word is and sounds like and override the referential cues that were used in the current study.

While the development of a more abstract phonological system in the second year of life may explain 20-month-old infants' lack of success with the click words in the present study, it is known, however, that children and adults do of course manage to learn new languages that sound quite different from their native tongue(s). One potential explanation for our results is that by 20 months, infants have sufficient familiarity with the speech sounds used in their native language that to learn labels containing non-native speech sounds, cues to reference need to be quite explicit. This would help explain why, using a task with overt social and referential cues (including pointing and interactive learning), Bijeljac-Babic et al. (2009) found that French-learning 20-month-old infants showed success in learning nonsense words presented in both English and French language sentential contexts.

Additionally, as noted previously, the click sounds in the words used in the present studies fall far outside the native language phonological inventory of the English-learning infants tested in our studies (for more on English speakers' perceptions of click sounds, see Discussion in Best & McRoberts, 2003) and as such were much more phonologically distinct from the native language than those used by Bijeljac-Babic et al. (2009). Thus, while they are independent processes, degree of phonological distinctiveness may interact with the explicitness of the referential cues in predicting success in a word-learning task. An important direction for future research will be to investigate how phonologically similar to the native language words must be for older infants to successfully learn them as object labels in tasks similar to those used in the present studies.

While we have described the stimuli used in the current studies as non-native words, a limitation of the present research is that we do not know that the infants actually perceived these stimuli as language. The stimuli are actual words in the N|uu language, meaning grasshopper (“||u”) and hartebeest (“!a”). Further, for both labels, the click sounds occurred within the context of a consonant-vowel syllable consistent with a word-like structure, and the vowel sounds were familiar to both English and N|uu. Nonetheless, we cannot conclude with certainty that the infants in our study did perceive the click words as unusual-sounding speech, rather than nonlanguage. Indeed, the developmental pattern of results observed in which younger, but not older, infants successfully map the click words to objects closely follows that which has been reported for infants' learning of nonlanguage labels (Namy & Waxman, 1998; Woodward & Hoyne, 1999). This will be important to disambiguate in future studies, perhaps utilizing neuroimaging methods, to ascertain whether the language areas of the brain are activated for non-native, unfamiliar-sounding words such as the click words used in the current study.

In summary, we examined two important cues available to infants in a word-learning situation: the phonological form of a label and the availability of referential intent. We found that in the presence of referential cues, younger infants as well as older infants with smaller vocabularies learn unfamiliar-sounding non-native words as object labels, but as infants develop and establish a more sizeable lexicon, they are more restrictive in the range of forms they succeed in learning as labels.

ACKNOWLEDGMENTS

This work was supported by a grant to Janet F. Werker from the National Sciences and Engineering Research Council of Canada (81103) and University of British Columbia graduate fellowships to Lillian May. We thank Amanda Miller for use of her N|uu stimuli and advice, as well as Laurel Fais and Savannah Nijeboer for comments on earlier drafts.

REFERENCES

- Baldwin, D. A. (1993). Early referential understanding: Infants' ability to recognize referential acts for what they are. *Developmental Psychology*, *29*, 832–843.
- Baldwin, D. A. (1995). Understanding the link between joint attention and language. In C. Moore, & P. J. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp. 131–158). Hillsdale, NJ: Lawrence Erlbaum Associates Inc.
- Baldwin, D. A., Markman, E. M., Bill, B., Desjardins, R. N., & Irwin, J. M. (1996). Infants' reliance on a social criterion for establishing word-object relations. *Child Development*, *67*, 3135–3153.
- Best, C. T. (1994). The emergence of native-language phonological influences in infants: A perceptual assimilation model. In J. C. Goodman, & H. C. Nusbaum (Eds.), *The development of speech perception: The transition from speech sounds to spoken words* (pp. 167–224). Cambridge, MA: The MIT Press.
- Best, C. T., & Avery, R. A. (1999). Left-hemisphere advantage for click consonants is determined by linguistic significance and experience. *Psychological Science*, *10*, 65–70.
- Best, C. T., & McRoberts, G. W. (2003). Infant perception of non-native contrasts that adults assimilate in different ways. *Language and Speech*, *46*(2–3), 183–216.
- Best, C. T., McRoberts, G. W., & Goodell, E. (2001). Discrimination of non-native consonant contrasts varying in perceptual assimilation to the listener's native phonological system. *The Journal of the Acoustical Society of America*, *109*(2), 775.
- Best, C. T., McRoberts, G. W., & Sithole, N. T. (1988). Examination of perceptual reorganization for nonnative speech contrasts: Zulu click discrimination by English-speaking adults and infants. *Perception*, *14*(3), 345–360.
- Bijeljac-Babic, R., Nassurally, K., Havy, M., & Nazzi, T. (2009). Infants can rapidly learn words in a foreign language. *Infant Behavior and Development*, *32*, 476–480.
- Byers-Heinlein, K., Burns, T. C., & Werker, J. F. (2010). The roots of bilingualism in newborns. *Psychological Science*, *21*, 343–348.

- Campbell, A. L., & Namy, L. L. (2003). The role of social-referential context in verbal and nonverbal symbol learning. *Child Development, 74*, 549–563.
- Cohen, L. B., Atkinson, D. J., & Chaput, H. H. (2002). *Habit 2002: A new program for obtaining and organizing data in infant perception and cognition studies (Version 1.0) [Computer software]* Austin: University of Texas.
- Curtin, S., & Werker, J. F. (2007). The perceptual foundations of phonological development. In G. Gaskell (Ed.), *The Oxford Handbook of Psycholinguistics* (pp. 579–599). Oxford: Oxford University Press.
- Fais, L., Werker, J. F., Brown, C., Leibowich, J., Barbosa, A. V., & Vatikiotis-Bateson, E. (2012). Here's looking at you, baby: What gaze and movement reveal about minimal pair word-object association at 14 months. *Journal of Laboratory Phonology, 3*, 91–124.
- Fennell, C. T., Byers-Heinlein, K., & Werker, J. F. (2007). Using speech sounds to guide word learning: The case of bilingual infants. *Child Development, 78*, 1510–1525.
- Fennell, C., & Waxman, S. R. (2010). What paradox? Referential cues allow for infant use of phonetic detail in word learning. *Child Development, 81*(5), 1376–1383.
- Fenson, L., Pethick, S., Renda, C., Cox, J., Dale, P., Reznick, J., et al. (2000). Short-form versions of the MacArthur communicative development inventories. *Applied Psycholinguistics, 21*, 95–116. Cambridge University Press.
- Graf-Estes, K., Edwards, J., & Saffran, J. R. (2011). Phonotactic constraints on infant word learning. *Infancy, 16*, 180–197.
- Graf-Estes, K., Evans, J. L., Alibali, M., & Saffran, J. R. (2007). Can infants map meaning to newly segmented words? Statistical segmentation and word learning. *Psychological Science, 18*, 254–260.
- Hollich, G. J., Hirsh-Pasek, K., Golinkoff, R. M., Brown, E., Chung, H. L., Hennon, E., et al. (2000). Breaking the language barrier: An emergentist coalition model for the origins of word learning. *Learning, 65*, 1–135.
- Johnson, E. K., & Jusczyk, P. W. (2001). Word segmentation by 8-month-olds: When speech cues count more than statistics. *Journal of Memory and Language, 44*(4), 548–567.
- Jusczyk, P. W., Cutler, A., & Redanz, N. (1993). Infants' preference for the predominant stress patterns of English words. *Child Development, 64*, 675–687.
- Jusczyk, P. W., Friederici, A. D., Wessels, J. M. I., Svenkerud, V. Y., & Jusczyk, A. M. (1993). Infants' sensitivity to the sound patterns of native language words. *Memory and Language, 32*, 402–420.
- Kuhl, P. K., Conboy, B. T., Coffey-Corina, S., Padden, D., Rivera-Gaxiola, M., & Nelson, T. (2008). Phonetic learning as a pathway to language: New data and native language magnet theory expanded (NLM-e). *Philosophical Transactions of the Royal Society B, 363*, 979–1000.
- MacKenzie, H., Curtin, S., & Graham, S. A. (2012). 12-month-olds' phonotactic knowledge guides their word-object mappings. *Child Development, 83*(4), 1129–1136.
- MacKenzie, H., Graham, S. A., & Curtin, S. (2010). Twelve-month-olds privilege words over other linguistic sounds in an associative learning task. *Developmental Science, 14*, 249–255.
- MacKenzie, H. K., Graham, S. A., Curtin, S. A., & Archer, S. (2014). The flexibility of 12-month-olds' preferences for phonologically appropriate object labels. *Developmental Psychology, 50*(2), 422–430.
- Maddieson, I. (2011). Consonant inventories. In M. S. Dryer, & M. Haspelmath (Eds.), *The World Atlas of Language Structures Online*. Munich: Max Planck Digital Library, Chapter 1.
- May, L., Byers-Heinlein, K., Gervain, J., & Werker, J. F. (2011). Language and the newborn brain: Does prenatal language experience shape the neonate neural response to speech. *Frontiers in Language Sciences, 2*, 222.

- Mehler, J., Jusczyk, P. W., Lambertz, G., Halsted, N., Bertoincini, J., & Amiel-Tison, C. (1988). A precursor of language acquisition in young infants. *Cognition*, 29, 143–178.
- Miller, A. L., Brugman, J., Sands, B., Namaseb, L., Exter, M., & Collins, C. (2009). Differences in airstream and posterior place of articulation among N|uu clicks. *Journal of the International Phonetic Association*, 39, 129–161.
- Namy, L. L. (2001). What's in a name when it isn't a word? 17-month-olds' mapping on non-verbal symbols to object categories. *Infancy*, 2, 73–86.
- Namy, L. L., & Waxman, S. R. (1998). Words and gestures: Infants' interpretations of different forms of symbolic reference. *Child Development*, 69, 295–308.
- Nazzi, T., & Bertoincini, J. (2003). Before and after the vocabulary spurt: Two mode of word acquisition? *Developmental Science*, 6, 136–142.
- Pater, J., Stager, C. L., & Werker, J. F. (2004). The perceptual acquisition of phonological contrasts. *Language*, 80, 384–402.
- Saffran, J. R., Werker, J. F., & Werner, L. A. (2006). The infant's auditory world: Hearing, speech, and the beginnings of language. In W. Damon, R. M. Lerner (Series Eds.), R. Siegler & D. Kuhn (Vol. Eds.), *Handbook of child psychology: Vol.2, cognition, perception and language*. New York: Wiley.
- Sato, H., Hirabayashi, Y., Tsubokura, H., Kanai, M., Ashida, T., Konishi, I., et al. (2011). Cerebral hemodynamics in newborn infants exposed to speech sounds: A whole-head optical topography study. *Human Brain Mapping*, 33(9), 2092–2103.
- Schafer, G., & Plunkett, K. (2008). Rapid word learning by fifteen-month-olds under tightly controlled conditions. *Child Development*, 69(2), 309–320.
- Stager, C. L., & Werker, J. F. (1997). Infants listen for more phonetic detail in speech perception than in word learning tasks. *Nature*, 388, 381–382.
- Swingle, D. (2009). Contributions of infant word learning to language development. *Philosophical Transactions of the Royal Society B*, 364, 3617–3622.
- Thiessen, E. D. (2007). The effect of distributional information on children's use of phonemic contrasts. *Journal of Memory and Language*, 56(1), 16–34.
- Traill, A. (1994) *A !Xhóõ Dictionary*. Köln: Rüdiger Köppe Verlag.
- Werker, J. F., Byers-Heinlein, K., & Fennell, C. (2009). Bilingual beginnings to learning words. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364, 3649–3663.
- Werker, J. F., Cohen, L. B., Lloyd, V. L., Casasola, M., & Stager, C. L. (1998). Acquisition of word-object associations by 14-month-old infants. *Developmental Psychology*, 34, 1289–1309.
- Werker, J. F., & Curtin, S. (2005). PRIMIR: A developmental framework of infant speech processing. *Language Learning and Development*, 1, 197–234.
- Werker, J. F., Fennell, C. T., Corcoran, K., & Stager, C. L. (2002). Infants' ability to learn phonetically similar words: Effects of age and vocabulary size. *Infancy*, 3(1), 1–30.
- Werker, J. F., & Tees, R. C. (1984). Cross-language speech perception evidence for perceptual reorganization during the first year of life. *Infant Behavior and Development*, 7, 49–63.
- Woodward, A. L., & Hoyme, K. L. (1999). Infants' learning about words and sounds in relation to objects. *Child Development*, 70, 65–77.
- Woodward, A. L., Markman, E. M., & Fitzsimmons, C. M. (1994). Rapid word learning in 13- and 18-month-olds. *Developmental Psychology*, 30(4), 553–566.