Developmental Science

Developmental Science 11:1 (2008), pp 53–59 DOI: 10.1111/j.1467-7687.2007.00645.x

REPORT

Fourteen-month-olds pay attention to vowels in novel words

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Abstract

Recent research has shown that infants are sensitive to mispronunciations of words when tested using a preferential looking task. The results of these studies indicate that infants are able to access the phonological detail of words when engaged in lexical recognition. However, most of this work has focused on mispronunciations of consonants in familiar and novel words. Very little is known about the role that vowels play in constraining lexical access during the early stages of lexical development. We describe a word learning study with 14- and 18-month-old infants that tests their sensitivity to mispronunciations of word-medial vowels using a preferential looking task. We found that both age groups demonstrated recognition of correctly pronounced tokens of the newly learnt words but not mispronounced tokens. These results indicate that vowels constrain lexical access of novel words by as early as 14 months of age, and add to the growing body of literature indicating that infants exploit detailed phonological information when processing both familiar and newly learnt words.

Introduction

By about 14 months of age, infants show sensitivity to mispronunciations of familiar words (Bailey & Plunkett, 2002; Ballem & Plunkett, 2005; Fennell & Werker, 2003; Swingley & Aslin, 2000, 2002). These studies have shown that infants look longer at a target object when its label has been correctly pronounced than when the label has been mispronounced at word onset (Ballem & Plunkett, 2005; Swingley & Aslin, 2002). Recent experiments have also shown that this effect is not restricted to consonant mispronunciations (Mani & Plunkett, 2007). By as early as 18 months, infants look longer at and show faster latencies in switching to a target object when its label is correctly pronounced than when the label has been mispronounced by a word-medial vowel.

Sensitivity to mispronunciations of word-initial consonants does not appear to be constrained by the level of infants' familiarity with the stimulus (Ballem & Plunkett, 2005; but see Swingley & Aslin, 2007; Swingley, in press). Using the inter-modal preferential looking task, Ballem and Plunkett found that 14-month-olds possess detailed phonological representations of the initial consonants of novel words. After training infants on two novel words, infants showed an increase in the target looking for correct pronunciations of the novel words but not for mispronunciations. Similar results have been found using a habituation task, where infants were habituated to novel words in carrier phrases (Fennell, 2006). It is argued that increasing the referential context in which novel words are presented to infants appears to have an effect on the sensitivity of the habituation task in examining the phonological specificity of infants' representations (cf. Stager & Werker, 1997). These findings suggest that 14-month-olds possess phonologically detailed representations of novel words, in some word learning situations. Notably, both these studies tested infants' sensitivity to mispronunciations of the *consonants* in novel words.

Some researchers have argued that consonants and vowels play distinct roles in lexical processing and representation. It has been found that adults are more likely to change a non-word into a word by altering the vowel than the consonant, suggesting that vowels may be less crucial to lexical identity than consonants (Cutler, Sebastian-Galles, Soler-Villageliu & van Ooijen, 2000; Van Ooijen, 1996). According to Nespor, Pena and Mehler (2003), differences in the roles of vowels and consonants may surface early in life, with consonants playing a more central role during lexical acquisition, whereas vowels provide information about prosody and grammatical acquisition.

This standpoint receives some support from a recent study by Nazzi (2005), comparing the role of vowels and consonants in constraining lexical acquisition of novel words using a name-based categorization task (Nazzi, 2005; Nazzi & Gopnik, 2001). Twenty-month-old French infants were presented with three novel objects and two novel labels (two of the objects shared the same novel label). The two labels differed either by a single consonant or a single vowel. Infants were then presented with one of the objects and asked to produce the other object with the same label. They found that infants

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could use the two labels to select the appropriate objects when the two labels differed by a single consonant, but *not* by a single vowel. Nazzi argued that these results suggest 'a greater reliance on consonants [than vowels] at the lexical level in infancy' (2005, p. 28).

In contrast, using the inter-modal preferential looking task, Mani and Plunkett (2007) found that vowels can constrain lexical access of familiar words in 18-month-old English infants. Furthermore, there appears to be no difference in infants' sensitivity to mispronunciations of vowels and consonants in familiar words at 18 months old. The difference between the results of Mani and Plunkett (2007) and Nazzi (2005) might be explained by differences in the specification of vowels in novel and familiar words; or by the difference between the tasks used in the two studies. The phonological specificity of vowels in infants' representations of novel words is yet to be examined using the inter-modal preferential looking task, which may provide a more sensitive measure of the role of vowels in acquiring new words (Ballem & Plunkett, 2005).

In order to explore the phonological specificity of vowels in English infants' representations and/or processing of novel words, the current experiment trained 14- and 18-month-olds on two novel word–object pairings. Infants were then presented with both objects and tested on either correct or incorrect pronunciations of the novel labels. If vowels are central to recognition of the lexical identity of novel words, then infants should look longer at a target object when its label is correctly pronounced than when it is mispronounced. If vowels do not constrain lexical access of novel words, infants should show an equal preference for the target object following either correct or incorrect pronunciations.

Method

Participants

The participants in this experiment were 33 infants at 14 months (M = 13.87 months; range: 13.4 to 14.72 months) and 30 infants at 18 months (M = 17.7 months; range: 17.03 to 18.23 months). Twenty-four additional infants were tested but were excluded from this study due to fussiness (three), experimenter error (two), or non-completion of the task (nine at 14 months; 10 at 18 months). All infants had no known hearing or visual problems and came from homes where British English was the only language in use. All parents were asked to complete the Oxford Communicative Developmental Inventory (OCDI; Hamilton, Plunkett & Schafer, 2000), a British adaptation of the MacArthur-Bates CDI (Fenson, Dale, Reznick, Thal, Bates, Hartung, Pethick & Reilly, 1993).

Stimuli

The speech stimuli were two novel words *padge* [pæʤ] and *mot* [mɔt]. Infants were tested on their sensitivity to mispronunciations of these words, where mispronunciations changed only the vowels of the words. *Padge* was mispronounced as *poudge* [puːʤ] and *mot* was mispronounced as *mit* [mɪt]. The chosen mispronunciations caused a change in roundedness, frontness, and height of the vowel in both cases. Each label, correct or incorrect, was recorded four times, in order to present each infant with four versions of each label. The duration, maximum pitch, and intensity of the correctly and incorrectly pronounced labels are given in Table 1. There were no systematic differences in the duration ($t(7)$ = .159; p = .87), pitch ($t(7)$ = .838; p = .43) or intensity ($t(7)$ = .00; p = 1.0) of the correctly and incorrectly pronounced words.

The speech stimuli were produced by a female speaker of British English in an enthusiastic, child-directed manner. The audio recordings were made with a Marantz PMD670 solid state recorder, at a sampling rate of 44.1 kHz and a resolution of 16 bits and spliced using Goldwave v. 5.10.

During an interactive play phase, infants were presented with two toys (displayed in Figure 1), followed by on-screen familiarization and testing phases, where infants were presented with animated videos of the same objects. The two images measured 32 cm × 32 cm and were separated by 15 cm when appearing simultaneously on the screen. The objects rotated around the vertical axis in familiarization, training, and testing trials in order to maintain infants' interest during the experiment.

Table 1 *Duration, maximum pitch and intensity of the correctly and incorrectly pronounced labels*

		Correct pronunciations			Incorrect pronunciations		
Label	Testing block	Duration (ms)	Pitch (Hz)	Intensity (dB)	Duration (ms)	Pitch (Hz)	Intensity (dB)
Padg	1	712	496	83	722	499	85
Padg	1	696	506	84	733	499	85
Padg	2	729	505	82	719	499	84
Padg	2	663	496	80	733	521	83
Mot	1	695	485	84	645	470	81
Mot	1	708	484	80	692	469	81
Mot	2	708	484	84	689	484	81
Mot	2	663	518	81	623	500	78
Mean		696	496	82	694	492	82

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Figure 1 *Objects presented to infants.*

Procedure

During the interactive play phase, infants sat on their caregiver's lap in front of the experimenter. A camera located behind the experimenter recorded infants' actions during the play phase. During the on-screen training and testing phases, infants sat on their caregiver's lap approximately 80 cm away from a projection screen (130 cm × 35 cm). Two cameras mounted directly above the visual stimuli recorded infants' eye movements. Synchronized signals from the two cameras were then routed via a digital splitter to create a recording of two separate time-locked images of the infant. Following the initial interactive play phase, each infant experienced a period of on-screen familiarization with the two objects, followed by two blocks of training and testing. The on-screen phase of the experiment thus consisted of a sequence of familiarization-training-testing-training-testing.

Off-screen training: play phase

During the play phase, infants were allowed to play with each of the objects individually, while the experimenter labelled the object six times using the following sentences:

> 'Ooh! Look! This one's a X! Look! It's a X! Do you want to play with the X? Can you say X? Ooh! Look! Where's the X? Look! Here's the X!'

Infants were trained on both label–object associations in a similar manner. The labels associated with the images were counterbalanced across infants – half of the infants were instructed that Object 1 was a *mot* and Object 2 was a *padge*. The other half was instructed that Object 2 was a *mot* and Object 1 was a *padge*. Object–label associations were maintained during on-screen and off-screen training phases. Order of presentation of objects and assignment of labels to each object in each order was counterbalanced across infants.

On-screen phase

Familiarization

During familiarization trials, infants were presented with videos of one of the objects for 5 seconds. During the first second of presentation, the object remained still. One second after the onset of the visual presentation, the object began to rotate about the vertical axis for the remainder of the trial. An enthusiastic child-directed voice directed their attention to the object using one of two auditory stimuli – '*Hey, look! You know this!*' or '*Ooh look! Remember this?*' Each object was presented to infants once during familiarization. The pairing of the attention-directing auditory stimuli with the video images and the side on which the image appeared was counterbalanced across infants. The order of appearance of the video images was randomized.

Training

Infants were presented with four training trials, during which they were exposed to video images of one of the objects for 5 seconds in each trial. The objects rotated in exactly the same manner as in the familiarization and training phases. The objects were labelled twice in each trial in one of two carrier phrases – '*This one's a X! X!*', '*Look at the X! X!*' The onset of the first token of the novel word 'X' was at 2500 ms after onset of the visual stimulus and the onset of the second token was at 4000 ms.

Infants saw each novel object twice during training. Consequently, infants heard each label four times during training. The carrier phrases varied in order to retain infants' interest in the experiment. Images appeared equally often to the left and to the right. The carrier phrases associated with the labels were counterbalanced within each block. Object–label associations from the play phase were maintained. Order of presentation of the trials was randomized.

Testing

Infants were presented with four testing trials in each block of testing, each trial consisting of the simultaneous presentation of both images side-by-side on a screen for 5 seconds. The objects rotated in exactly the same manner as in the familiarization and training phases. Halfway through the trial, one of the objects was labelled with either a correct or incorrect pronunciation of the

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target label. The target label appeared in one of two carrier phrases – '*Can you see the X? X!*' and '*Which one's the X? X!*' The onset of the first token of the target label was at 2500 ms; dividing the trial into a pre- and a post-naming phase. The onset of the repeated token of the target label was at 4000 ms. Infants heard correct and incorrect pronunciations of both target labels in each block, thus presenting infants with two correct pronunciations of each word, and two mispronunciations of each word across both blocks. Targets for correct and incorrect pronunciations appeared equally often to the left and to the right. Order of presentation of trials was randomized within each block. The second block of training and testing trials immediately followed the first block.

Scoring

A digital-video scoring system was used to assess visual events on a frame-by-frame basis (every 40 ms). The coded video frames were used to determine the amount of time infants looked at the target and distracter images in the two phases of each trial; before and after the onset of the target word. As in previous research, it was assumed that the amount of time required by infants to initiate an eye movement was 367 ms (Swingley, Pinto & Fernald, 1999; Swingley & Aslin, 2000, 2002). Consequently, analysis of the post-naming phase of the trial was initiated 367 ms after the onset of the target word. In addition, only those trials in which infants fixated both the target *and* the distracter during the entire trial were included in the analysis.

The amount of time infants spent looking at the target divided by the amount of time spent looking at the target and distracter was used to determine the *proportion of target looking* (PTL) in both phases of the trial (Schafer & Plunkett, 1998; Meints, Plunkett & Harris, 1999; Swingley & Aslin, 2000; Bailey & Plunkett, 2002). We then calculated the difference in the proportion of target looking between the pre- and the post-naming phases of the trial (the effect of naming). A significant difference in this effect of naming between the two pronunciation conditions would provide evidence of infants' sensitivity to mispronunciations of the vowels in novel words.

We also calculated the difference between *infants' longest look* (LLK) at target and distracter images before and after target word onset used in earlier studies (Schafer & Plunkett, 1998; Meints *et al*., 1999; Bailey & Plunkett, 2002; Ballem & Plunkett, 2005). As in the PTL measure, we computed the effect of naming separately for both pronunciation conditions.

Some studies report the amount of time taken by infants to switch from the distracter image to the target image upon hearing the target label as an index of infants' preference for the target image (Swingley & Aslin, 2000, 2002; Fernald, Swingley & Pinto, 2001). We compared infant responses to correct and mispronunciations of novel labels using this latency measure. Only eye movements 367 ms after the onset of the target word were considered. A rapid change in gaze after this point is taken as a measure of infants' detection of a mismatch between the picture currently fixated and the target label. As far as we are aware, this is one of the first studies using the latency measure in a novel word learning study (see also Zangl & Fernald, in press). PTL and LLK are most commonly used to assess the learning of object–label association in IPL tasks (Schafer & Plunkett, 1998; Schafer, 2005; Houston-Price, Plunkett & Harris, 2005).

Results

We calculated the difference in infants' preference for the target image between the pre- and post-naming phases of the trial (Effect of naming = Post-naming target preference$_{\text{LLK or PTL}}$ – pre-naming target preference$_{\text{LLK or PTL}}$). Table 2 presents the difference in infants' preference for the target image between the pre- and post-naming phases of the trial tabulated by pronunciation type and age for both the PTL and LLK measures. The data in Table 2 suggest that there is an increase in infants' preference for the target when presented with correct pronunciations in both age groups, but not when presented with mispronunciations. For the sake of clarity, the data are also presented graphically in Figure 2, using the LLK measure.

Combining the data from both age groups, we ran a mixed model ANOVA with testing block (Block 1 and Block 2) and accuracy of pronunciation as within-subject factors and age as a between-subjects factor using the LLK data. There was a significant effect of pronunciation

Table 2 *Effect of naming separated by age and pronunciation type using both PTL and LLK measures (Effect of naming = Post-naming target preference – pre-naming target preference)*

	Effect of naming							
	Longest look measure				Proportion of target looking measure			
	Correct pronunciations		Incorrect pronunciations		Correct pronunciations		Incorrect pronunciations	
Age	Mean	SE	Mean	SE	Mean	SE	Mean	SE
14 months	650	265	–122	253	.15	.06	–.05	.06
18 months	969	334	140	308	.20	.07	.06	.06

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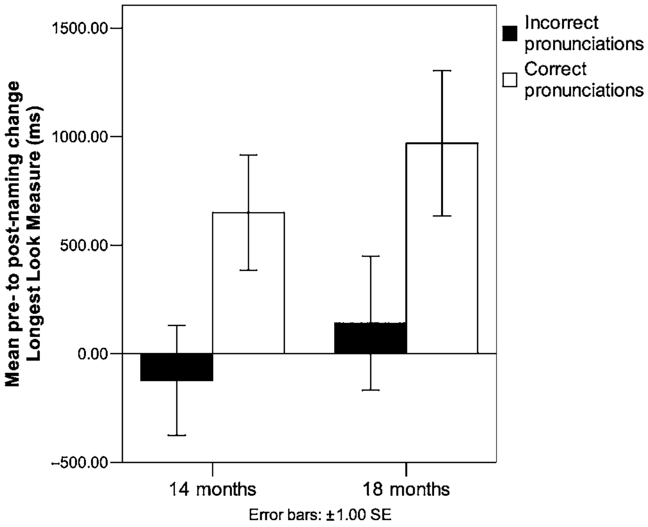

Figure 2 *Effect of naming separated by age and pronunciation type using LLK measure.*

type (F(1, 61) = 9.670, p = .003). There were no significant main effects of block (F(1, 61) = .483, p = .49) or age (F(1, 61) = .83, p = .36), or any significant interactions between pronunciation and age (F(1, 61) = .012, p = .91) or block and age (F(1, 61) = 2.16, p = .14).

A similar pattern of results was found using the PTL data. There was a significant effect of pronunciation type (F(1, 61) = 8.106, p = .006), but not of block (F(1, 61) = .36, p = .55) or age (F(1, 61) = 1.2, p = .26). There were no significant interactions between pronunciation and age (F(1, 61) = .24, p = .62) or block and age (F(1, 61) = 1.52, p = .22).

Despite the absence of a main effect of age, we separately confirmed the main effect of pronunciation type in both age groups in order to ensure that the effect was not driven by either group of infants (14 months: F(1, 32) = 4.966, p = .033, 18 months: F(1, 29) = 4.695, p = .039).

We also performed a separate items analysis to see whether there were any differences in infants' learning of the novel labels or their sensitivity to mispronunciations of the novel labels. Not all infants provided data for both correct and incorrect pronunciations of both words, reducing the number of infants who were included in this analysis. A mixed model ANOVA with pronunciation (correct and incorrect) and item (*mot* and *padge*) as within-subjects' factors revealed a significant main effect of pronunciation using both PTL (F(1, 52) = 4.82, p = .03) and LLK measures (F(1, 52) = 5.82, p = .019). However, there was no significant main effect of item (PTL: F(1, 52) = 1.60, p = .21; LLK: F(1, 52) = 1.3, p = .24) or significant interaction between item and pronunciation (PTL: F(1, 52) = .38, p = .53; LLK: F(1, 52) = .34, p = .56). This analysis suggests that there were no systematic differences in infants' learning of the two novel labels or their sensitivity to mispronunciations of these labels.

Planned comparisons

Planned comparisons revealed that the effect of naming following correct pronunciations was significantly different from chance (set at 0) using both LLK (14 months: t(32) = 2.449, p = .02; 18 months: t(29) = 2.90, p = .007) and PTL measures (14 months: t(32) = 2.207, p = .035; 18 months: t(29) = 2.67, p = .012). However, the effect of naming following incorrect pronunciations was not significantly different from chance using either LLK (14 months: t(32) = –.48, p = .63; 18 months: t(29) = .45, p = .65) or PTL measures (14 months: t(32) = –.83, p = .41; 18 months: t(29) = .95, p = .34). These results indicate that infants are sensitive to mispronunciations of the vowels even in novel words.

Latency analysis

Latency analyses considered the data from only those infants who switched from the distracter to the target image at disambiguation in at least one trial for both correct and incorrect pronunciations. Infants fixated the distracter picture at the disambiguation point (367 ms after onset of target word) in 41.5% (14 months: 42%; 18 months: 41%) of all trials and they switched from the distracter to the target image in 30.5% of all trials (14 months: 32%; 18 months: 29%). Forty infants provided latency measures for both conditions (14 months: 22 infants; 18 months: 18 infants). Infants took an average of 800 ms to switch from the distracter to the target image upon hearing correct pronunciations of the target label (14 months: M = 804 ms, SE = 77 ms; 18 months: M = 795 ms, SE = 100 ms) and an average of 977 ms to switch from the distracter to the target image upon hearing incorrect pronunciations of the target label (14 months: M = 954 ms, SE = 108 ms; 18 months: M = 1006 ms, SE = 78 ms). A mixed model ANOVA with pronunciation accuracy as a within-subjects factor and age as a between-subjects factor found a main effect of pronunciation (F(1, 38) = 4.988, p = .031). There was no main effect of age (F(1, 38) = .04, p = .84) or interaction between pronunciation and age (F(1, 38) = .13, p = .71). Infants switch faster to the target picture upon hearing a correct pronunciation compared to a mispronunciation.

Effect of vocabulary size

We calculated the mean receptive percentile vocabulary size of the infants based on parental OCDI reports (14 months: M = 17.2%; SD = 10.95%; range: 0–54%; 18 months: M = 42.2%; SD = 18.8%; range: 0–73%). We measured the correlation between infants' vocabulary size and their sensitivity to mispronunciations (the difference in naming effect between correct and mispronounced labels). There was no evidence for any correlation (PTL: r = .064, p = .61; LLK: r = .008, p = .95). We also calculated the mean productive percentile vocabulary size of the infants (14 months: M = 2.6% words;

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SD = 0.8%; range: 0–6%; 18 months: $M = 24.4\%$; SD = 16.4%; range: 0–48%). There was no evidence for any correlation between infants' productive vocabulary size and their sensitivity to mispronunciations (PTL: $r = .073$, $p = .57$; LLK: $r = -.058$, $p = .65$). Hence, we find no evidence for a relationship between the phonological specificity of infants' lexical representations and the size of infants' productive or receptive vocabulary (as measured by the OCDI), thereby confirming the findings of earlier studies (Swingley & Aslin, 2000, 2002; Bailey & Plunkett, 2002; Ballem & Plunkett, 2005).

Discussion

The results indicate that infants show sensitivity to mispronunciations of the vowels in novel words by as early as 14 months of age. Infants look longer at a target object when the target label has been correctly pronounced, compared to a pre-naming salience period. Conversely, they do not look longer at a target object when the target label has been incorrectly pronounced on the word-medial vowel. In addition, there was a significant difference in infants' looking behaviour when presented with correct and incorrect pronunciations of the target labels. These findings indicate that 14-month-olds encode sufficient phonological information of the vowels of novel words such that changes to the vowel impede recognition of a target label. The pattern of findings was stable across all measures analysed, including LLK, PTL and latency. The finding that the latency measure produced a similar result to the more standard indexes used in IPL to measure the level of object–word associations (PTL and LLK) indicates that latency is of utility not only in assessing infant processing of familiar words (Swingley & Aslin, 2000, 2002; Fernald *et al.*, 2001) but as a measure of novel word learning too.

Previous results have demonstrated that infants are sensitive to mispronunciations of the word-initial consonants in novel and familiar words by 14 months of age (Ballem & Plunkett, 2005; Swingley & Aslin, 2002). Notwithstanding Nespor *et al.*'s claim that the 'task of distinguishing lexical items rests more on consonants than on vowels' (Nespor *et al.*, 2003, p. 209), our results together with those of previous studies (Mani & Plunkett, 2007) suggest that vowels also play an important role in constraining lexical access of novel and familiar words by as early as 18 months of age. Our results contrast with the finding that 20-month-old French infants cannot learn two novel words that differ only by a single vowel (Nazzi, 2005). Indeed, the latter results might be interpreted to indicate that vowels do not play a central role in lexical acquisition by infants. Of course, the task differences between Nazzi (2005) and the current study may play an important role in explaining the differences in the results. In keeping with the *resource limitation hypothesis* (Stager & Werker, 1997; Fennell & Werker, 2003, 2004; Werker & Fennell, 2004), it is possible that the computational demands imposed by the categorization task employed by Nazzi caused infants to fail to pay attention to the phonetic detail of the vocalic nuclei of the novel labels. Conversely, the IPL task employed in the current study required infants to notice a match between a target object and its corresponding label (Ballem & Plunkett, 2005). IPL may make it easier to tap into the phonological specification of a lexical representation because of the lower demands imposed on the infant during task compliance.

It should be acknowledged that the current experiment does not directly compare the contribution of consonants and vowels to lexical acquisition. Consequently, we do not argue against the claim that consonants may be *more* important to lexical acquisition of novel words than vowels. For instance, in keeping with the results obtained by Nazzi (2005, p. 28), there may be a 'greater reliance on consonants [than vowels]' in more complicated word learning situations or in more complicated tasks. Indeed, this would be consistent with the psycholinguistic research on adults, whose findings suggest that vowels tend to be more expendable than consonants in lexical selection (Cutler *et al.*, 2000). Cutler *et al.* argue that linguistic experience could play a role in driving this asymmetry. For instance, listeners might be sensitive to the fact that all languages have more minimal pairs hinging on consonants than on vowels, making consonants more central to distinguishing words in the lexicon (see Cutler *et al.*, 2000, p. 754). It is possible that by 20 months of age, infants have had sufficient exposure to language to necessitate greater attention to consonants than vowels, *at least* while simultaneously learning minimal pairs. In the current study, infants have been introduced to one-half of both minimal pairs (i.e. the correct pronunciations) repeatedly during training. The contrast between correct and incorrect pronunciations may, in this context, be more salient, as the correct pronunciations are more familiar than the mispronunciations. We also note that the lack of any correlation between vocabulary size and naming effects suggests the absence of any direct link between overall language experience and sensitivity to mispronunciations.

Note also that our conclusion that infants are sensitive to mispronunciations of vowels in novel words is based on our testing infants' sensitivity to mispronunciations of just two words. This was a constraint imposed by the difficulty of teaching infants novel words in a laboratory setting. Most novel word learning studies do not attempt to teach infants more than two words (Tan & Schafer, 2005; Ballem & Plunkett, 2005; Swingley, in press; but see Swingley & Aslin, 2007, where although each infant is taught only two words, infants overall were exposed to four novel words). Even in testing infants' sensitivity to mispronunciations of familiar words, not more than six words have been usually tested (Ballem & Plunkett, 2005; Swingley & Aslin, 2000, 2002; though see Bailey & Plunkett, 2002, and Mani & Plunkett, 2007, where infants' sensitivity to consonant and vowel mispronunciations of

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at least 16 words were tested, respectively). Consequently, the current study represents a first step, albeit an important one, in exploring infants' sensitivity to vowel mispronunciations in novel words. Further studies, exploring a wider range of vowels and types of vowel mispronunciations, are needed to establish the generality of the present set of results.

Finally, although we provide evidence for the phonological specificity of infants' lexical representations of novel words, there is inadequate definition of the locus of this specificity. For instance, how many and what changes to vowel quality are necessary to trigger infants' sensitivity to a mispronunciation? The current study tested infants' sensitivity to large mispronunciations of the vowels in CVC words alone. Research on the phonological specificity of vowels in familiar words suggests that infants may be more sensitive to mispronunciations of vowel height and vowel backness than of vowel roundedness (Mani & Plunkett, in press). This result indicates that the extent of specification of vowels in familiar words goes beneath the segmental level. Future research needs to explore whether infants possess similarly detailed specification of the vowels in novel words.

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Received: 20 September 2006
Accepted: 25 March 2007

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