Research Report

LEXICAL NEIGHBORHOODS AND THE WORD-FORM REPRESENTATIONS OF 14-MONTH-OLDS

Daniel Swingley[1] and Richard N. Aslin[2]

[1]*Max-Planck-Institute for Psycholinguistics, Nijmegen, the Netherlands, and* [2]*Department of Brain and Cognitive Sciences, University of Rochester*

Abstract—*The degree to which infants represent phonetic detail in words has been a source of controversy in phonology and developmental psychology. One prominent hypothesis holds that infants store words in a vague or inaccurate form until the learning of similar-sounding* neighbors *forces attention to subtle phonetic distinctions. In the experiment reported here, we used a visual fixation task to assess word recognition. We present the first evidence indicating that, in fact, the lexical representations of 14- and 15-month-olds are encoded in fine detail, even when this detail is not functionally necessary for distinguishing similar words in the infant's vocabulary. Exposure to words is sufficient for well-specified lexical representations, even well before the vocabulary spurt. These results suggest developmental continuity in infants' representations of speech: As infants begin to build a vocabulary and learn word meanings, they use the perceptual abilities previously demonstrated in tasks testing the discrimination and categorization of meaningless syllables.*

To learn a spoken language, children must encode in memory the sound forms of words such that additional exemplars of those words can be identified correctly. This process is complicated by the fact that different realizations of a given word vary acoustically because of several factors irrelevant to lexical identity, such as differences in the speaker, the rate of speech, and the context within which the word appears. Word recognition depends on the ability to attend to linguistically relevant sound distinctions despite this variability. Although this extraction of phonetic invariance relies in part on basic perceptual mechanisms, it is also influenced by language-specific mechanisms: Just as words vary across languages, so do the sound distinctions that are relevant to distinguish these words.

Remarkably, experiments with infants suggest that the ability to attend specifically to phonologically relevant distinctions is present by the age of 12 months. Over the course of the 1st year, infants learn to distinguish sounds that the ambient language distinguishes, and to conflate sounds that the language conflates (Werker & Tees, 1984; for review, see Aslin, Jusczyk, & Pisoni, 1998). This suggests that right from the onset of word learning, infants can encode words in terms of the language's distinctive categories.

However, several experiments testing somewhat older infants' and young children's representations of words have supported the opposite conclusion: Words appear to be encoded only vaguely, with nonphonemic forms that lack phonetic specification (e.g., Garnica, 1973; Shvachkin, 1948/1973). In these experiments, children were taught novel names for two or more objects. The objects were then presented together, and the experimenter requested one of the objects by name. When the names differed by a single feature (e.g., *dak-gak*), children under about 24 months of age frequently failed to choose the correct object, although performance was good when the words were not similar. This pattern of results suggests that words are not encoded with full phonetic detail.

The discrepancy between infants' successful categorization performance and young children's inconsistent word-recognition performance has been attributed to task demands: Infants have usually been tested in discrimination procedures, whereas young children have been tested in referential tasks requiring more demanding overt selection responses (e.g., Locke, 1988). Of course, although this observation might account for the discrepancy in findings, it does not resolve questions about the nature of children's lexical representations. Some phonologists have assumed (partly on the basis of infant perception results) that children's perceptual representations of words are adultlike (e.g., Hayes, in press), while others have assumed they are not (e.g., Ferguson & Farwell, 1975; Menyuk, Menn, & Silber, 1986; Waterson, 1971).

Several researchers have suggested that imprecise encoding of words may suffice for young children who have small vocabularies, because in the early stages of word learning, children tend not to know words that are acoustically similar to each other (Charles-Luce & Luce, 1990; Jusczyk, 1993; Metsala & Walley, 1998; but see Coady & Aslin, 2002). The notion that children's lexical representations are gradually refined in step with children's functional need for this refinement suggests that detail in word forms corresponds closely to the *neighborhood structure* of the words: When a child knows two words that are acoustically similar to each other (*neighbors*), this perceptual proximity motivates greater attention to the words' distinguishing phonetic characteristics, and this attention leads to refinement of lexical representations. In contrast, words that have no neighbors are not encoded in detail because they have not had the benefit of this attentional "pressure."

Two recent lines of research have helped to shed some light on these questions by testing young children in referential tasks that do not demand overt selection responses. Experiments of this sort help bridge the gap between infant speech perception research and work on word representations in young children. One set of studies by Werker and her colleagues began with a test of 14-month-olds' ability to detect small phonemic changes in the pronunciation of a novel word (Stager & Werker, 1997). Infants were familiarized with a film of a moving novel object paired with a soundtrack consisting of several tokens of a novel word, such as *dih*. Once infants' looking times declined past a criterion, the word's pronunciation was changed (in this case, to *bih*). The infants failed to dishabituate (show a recovery in looking times) upon hearing the switch. This result is surprising because 8-month-olds dishabituated under the same circumstances; furthermore, 14-month-olds did dishabituate to this pronunciation change if the visual display was a checkerboard rather than a novel object. Stager and Werker argued that the developmental change occurred because only the 14-month-olds were attempting to learn the referential nature of words (and only when an object that could be labeled was visible). According to this account, infants learning word meanings do not attend to phonetic detail be-

Address correspondence to Daniel Swingley, Max-Planck-Institute for Psycholinguistics, Postbus 310, 6500-AH Nijmegen, Netherlands; e-mail: daniel.swingley@mpi.nl.

cause doing so would overwhelm their limited computational capacities. One interpretation of this result is that when words are first learned, infants' representations of them are vague; however, they might be refined over time as increasing familiarity reduces the attentional demands of encoding phonetic detail. In a follow-up study, Werker, Fennell, Corcoran, and Stager (2002) found that 17-month-olds and 20-month-olds do notice the switch in pronunciations, showing that the apparent word-encoding difficulties of 14-month-olds abate later in the 2nd year.

In another recent study, we evaluated older infants' representations of familiar words rather than newly taught words (Swingley & Aslin, 2000; see also Werker & Pegg, 1992). We reasoned that if early representations lack phonetic detail, young children should be indifferent to small variations in pronunciation. Using a visual fixation procedure, we tested children's ability to recognize correct pronunciations (CPs) of six words (e.g., *baby* and *dog*) and mispronunciations (MPs) of those words (*vaby* and *tog*). Children ranging from 18 to 23 months of age viewed pairs of pictures on a computer screen. One of the pictures was named using either a CP or an MP (e.g., *Where's the vaby?*). The children's eye movements were monitored to evaluate how much time they spent looking at the named target, relative to the distractor, and how quickly they shifted their gaze from the distractor to the target upon hearing the word. The children looked at the target significantly less upon hearing an MP than upon hearing a CP, although performance was above chance in both conditions. The children also recognized CPs significantly faster than MPs. The effects of mispronunciation on looking behavior were not correlated with the children's age, ability to pronounce the target words, or spoken vocabulary size (as estimated using the MacArthur Communicative Development Inventory: Words and Sentences; Fenson et al., 1994).

Taken together, these studies suggest that representations of newly learned words lack phonetic detail at 14 months and that representations of familiar words are encoded in detail by 18 months. In the present study, we used the mispronunciation method to test whether the apparent differences in phonetic specification across these studies were due to the different ages of the children tested (i.e., whether there are developmental differences in the nature of lexical representations within this age range) or to the children's experience with the words themselves (i.e., whether there is more detail in the representations of familiar words than newly learned words). In addition, we evaluated the potential contributions of neighborhood structure and receptive vocabulary size in the refinement of early lexical representations.

METHOD

The procedure was identical to that used in our previous study (Swingley & Aslin, 2000), except that the displayed pictures slowly moved up and down in synchrony, a manipulation intended to help maintain infants' interest in the display. Infants were seated on their parent's lap facing an 80-cm video monitor. Before the experiment began, the infants' attention was attracted to the monitor by a pair of short animated movies. The experiment proper consisted of 28 trials: 24 test trials and 4 fillers. Each test trial began with the presentation of two horizontally aligned pictures of objects. After 3 s, a prerecorded speech stimulus naming one of the pictured objects was played from a central loudspeaker. Sentences were of the form *Where's the [target]?* followed by *Can you find it, Do you like it,* or *Do you see it?* Filler trials with four pictures of other familiar objects were interspersed with test trials to help maintain the infants' interest.

Two kinds of mispronunciations were tested: close mispronunciations (MP-close) and distant mispronunciations (MP-distant). Each MP-close item was created by substituting a sound in the target's citation form with a similar sound (e.g., changing *dog* to *tog*); the corresponding MP-distant item was created by substituting a dissimilar sound (e.g., changing *dog* to *mog*). The close mispronunciations were the same as those we tested before (Swingley & Aslin, 2000). The MP-distant condition was added to help determine the range of acceptable forms recognized by infants in the event that effects of more subtle mispronunciations were not found. The full set of test stimuli is displayed in Table 1. The mean durations of the targets were 676 ms ($SD = 81$) for the CP condition, 676 ms ($SD = 108$) for the MP-close condition, and 705 ms ($SD = 97$) for the MP-distant condition. Sentences were recorded by a female native speaker of American English in an infant-directed register. Each infant heard either CP and MP-close targets or CP and MP-distant targets. Each of the target words was presented twice, and pictures were counterbalanced (as in Swingley & Aslin, 2000).

Parents were instructed to close their eyes and tilt their head downward when the trials began (peeking parents were excluded from the study). The infants' faces were videotaped; coding of the infants' gaze direction was completed off-line by several highly trained coders who stepped through the tape frame by frame. Following the experiment, the forms for the Communicative Development Inventory: Words and Gestures (Fenson et al., 1994), which had previously been completed by the parents, were collected.

The final sample included 50 infants, out of 77 tested. Attrition was due to fussiness (failure to attend on 17 or more test trials; $n = 13$), parental interference ($n = 2$), insufficient vocabulary (infant reported to know fewer than four of the tested words, $n = 6$), and experimenter error ($n = 6$). The mean age of the sample was 459 days (approximately 15 months 3 days; range: 14 months 4 days to 15 months 30 days). Twenty-six infants were assigned to the MP-close/CP condition, and 24 were assigned to the MP-distant/CP condition; the ages of these samples were not significantly different (*M*s = 459 and 460 days, respectively). An equal number of boys and girls was tested in each condition.

RESULTS AND DISCUSSION

Analyses of eye movements were conducted over a window extending from 367 to 2,000 ms after the onset of the target word, as in

Table 1. *Correctly pronounced (CP) target words and their mispronounced (MP) versions*

CP	MP-close	MP-distant
apple (/æpl̩/)	opple (/apl̩/)	opal (/opl̩/)
baby (/beɪbi/)	vaby (/veɪbi/)	raby (/ɹeɪbi/)
ball (/bɔl/)	gall (/gɔl/)	shawl (/ʃɔl/)
car (/kaɹ/)	cur (/kɝ/)	kier (/kiɹ/)
dog (/dɔg/)	tog (/tɔg/)	mog (/mɔg/)
kitty (/kɪti/)	pity (/pɪti/)	yitty (/jɪti/)

Note. International Phonetic Alphabet transcriptions are provided in parentheses. Bisyllabic words were stressed on the first syllable.

previous research. Infants' performance was evaluated by computing their proportion of fixations to the target picture.[1]

An analysis of variance (ANOVA) with condition (CP vs. MP) as a repeated measure and mispronunciation type (MP-close vs. MP-distant) as a between-subjects factor revealed that CP words were significantly easier to recognize than MP words, $F(1, 48) = 12.6$, $p < .001$, by subjects, and $F(1, 10) = 32.3$, $p < .001$, by items; there was no effect of MP type (all Fs < 0.3), and there were no interactions (all Fs < 0.1). The effect of condition held for all six tested words. Mean fixation proportions were as follows: MP-close infants, 60.2% for CPs and 53.4% for MPs; MP-distant infants, 61.4% for CPs and 54.2% for MPs. Each of these four proportions was significantly greater than 50%, indicating that the infants were able to recognize the words whether pronounced correctly or not (all ts > 2, except MP-close, $t[25] = 1.77$, $p = .045$, one-tailed).

Further analyses evaluated relationships between the infants' reported vocabularies and fixation responses, collapsing over MP type (the pattern of results and significance were equivalent in the MP-close and MP-distant analyses when considered separately). Reported comprehension vocabularies ranged from 18 to 296 words ($Mdn = 161.5$); reported production vocabularies ranged from 0 to 150 words ($Mdn = 12.5$). Performance in both the CP and the MP conditions was only weakly correlated with comprehension vocabulary ($r = .141$ and .175, respectively) and production vocabulary ($r = .182$ and .029, respectively, all ps $> .20$). Most important, the size of the mispronunciation effect (i.e., CP minus MP) was not correlated with either comprehension vocabulary size ($r = -.017$) or production vocabulary size ($r = .112$, both ps $> .20$).

Figure 1 (left panel) shows the size of the mispronunciation effect for each child, ordered by receptive vocabulary. It is clear that the MP effect held for most children, and that there was no relationship between effect size and reported vocabulary size. Nor was there a significant relationship between effect size and age (see Fig. 1, right panel; $r = .049$, $p > .20$), though there was some evidence of a relationship between age and performance on CP trials ($r = .26$, $p = .07$) and MP trials ($r = .20$, $p = .16$).

Many infants were reported to know one or more "neighbors" of the tested target words *ball*, *car*, or *dog* (where neighbor was defined as a word that could be turned into a target through addition, deletion, or substitution of one phoneme; e.g., Luce & Pisoni, 1998). No infants were reported to know neighbors of *apple*, *baby*, or *kitty*.[2]

If infants' vague representations of words are refined through attention to similarities between neighbors, mispronunciation effects would be predicted to be stronger for words having neighbors than for words not having neighbors; indeed, mispronunciation effects would not be expected for nonneighbors at all. However, neighborhood status had no impact on infants' behavior, as shown by an ANOVA with condition (CP vs. MP) and neighborhood status (at least one neighbor vs. no neighbors) as repeated measures and mispronunciation type (MP-close vs. MP-distant) as a between-subjects factor. The effect of condition was significant, $F(1, 40) = 8.2$, $p < .01$; no other main effects or interactions were significant (all ps $> .10$).[3] Thus, there was no indication that sensitivity to mispronunciation was limited to words for which infants already had neighbors in their lexicon.

In sum, for all six of the words tested, infants 14 and 15 months of age found mispronunciations harder to recognize than correct pronunciations, indicating that 1-year-olds' lexical representations are stored in detail, at least with respect to their onsets. This was true for infants reported to have small receptive vocabularies and when infants did not know any neighbors of the tested words. The results contradict accounts in which infants' words are stored as vague phonetic forms until expansion of the vocabulary forces attention to differences between similar-sounding words. Rather, infants encode words with a level of detail sufficient for distinguishing known words and similar-sounding novel words. As stated in the introduction, skilled word recognition requires the listener to attend to phonologically relevant variation (such as the distinction between *baby* and *vaby*) while ignoring irrelevant variation (such as that due to talker identity). By the age of 14 months, infants appear to have word representations well suited to this task.

Because a distant pronunciation like *mog* is less similar to *dog* than *tog* is (in any theory of phonetic similarity), we anticipated larger effects of mispronunciation for the distant mispronunciations than for the close ones; however, equally strong mispronunciation effects were found in the two conditions. Although more data would be needed for a conclusive explanation, we suspect that our null result on this factor reflects the fact that the effects of phonetic distance on word recognition are not linearly proportional to the number of phonetic features (or any other a priori phonetic-distance metric) incorrectly realized in a pronunciation. That is, under clear listening conditions, *any* mispronunciation may impair recognizability. Phonetic distance should have an impact, but variation due to distance may not be as influential as the mere fact of being a mispronunciation.

Our finding that infants encode words in detail allows for a simpler account of early lexical representations. The neighborhood-refinement view places the burden of phonological differentiation on word meaning: If *ball* and *doll* are initially taken to be homophonous, discovering that they are not would require infants to first recognize that a single, vague word form (*b/doll*) refers to two semantically disparate categories, and then to scrutinize the phonetics of this word form to differentiate the *b-d* distinction. However, as Brent and Cartwright (1996) pointed out, semantic categorization is a substantial problem in its own right and does not seem a robust foundation for phonological development. If infants are able to encode and categorize words in detail, as we suggest, it is not necessary to assume that word-form learning depends on corrective feedback from semantic analyses.

Our results contrast with data from experiments testing infants' responses to words they have just been taught. In those studies, infants under 17 months failed to differentiate acoustically similar words. One

1. In previous work with older children, we also analyzed *response latency* for trials on which infants fixating the distractor shifted to the target within the test window. However, 14-month-olds are less likely than older children to correctly shift, producing less reaction time (RT) data; as a result, estimates of RTs by condition by subject are rather variable. In the present study, analyses by trials, pooling over subjects, showed significantly slower responding to the MP words (1,036 ms) than the CP words (922 ms), $t(298) = 2.37$, $p = .009$, one-tailed.

2. Neighbors listed included *doll*, *bowl*, and *fall* (for *ball*); *doll* (for *dog*); and *cow* (for *car*). In this analysis, we employed a generous standard for counting neighbors, to be certain that the targets considered as having no neighbors indeed had no neighbors. However, if *doll* is not considered a neighbor of *ball* or *dog* (given that for many Rochester caregivers the vowel of *doll* is different), the analysis of neighborhood effects is unchanged.

3. This analysis excluded 7 infants who knew no neighbors of any target words. These 7 infants showed a significant mispronunciation effect (CP, 58%; MP, 49%), $t(6) = 2.1$, $p = .04$, one-tailed.

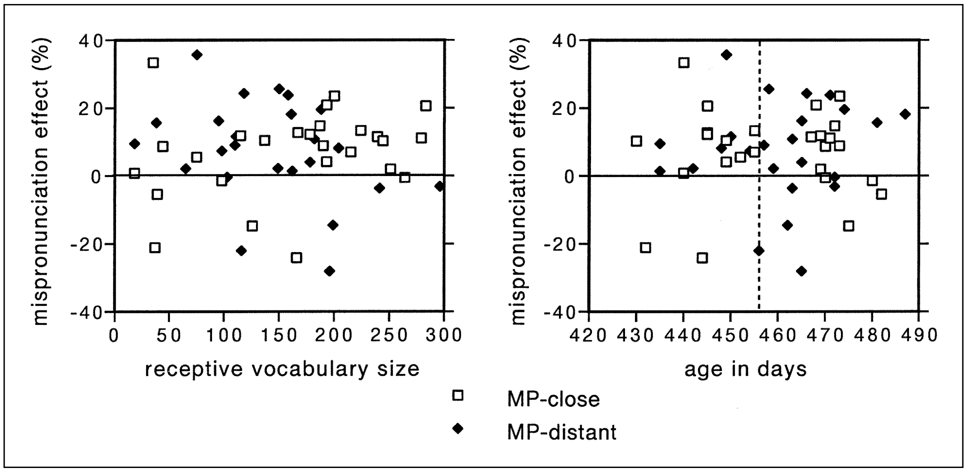

Fig. 1. Mispronunciation effect (proportion of fixations to the target for correctly pronounced words minus proportion of fixations to the target for mispronounced words) for each infant, arranged according to infants' receptive vocabulary sizes (left) and ages (right). Some infants heard close mispronunciations of the target words (MP-close), and others heard distant mispronunciations (MP-distant). The vertical dotted line in the right graph separates 14-month-olds from 15-month-olds.

obvious way to reconcile these divergent findings is to suppose that the initial encoding of lexical forms is vague, but once a word has been heard many times (or in many contexts and by different talkers), its representation is refined such that subtle mispronunciations no longer closely match the stored form. The infants in Stager and Werker's (1997) study (Experiments 2, 3, and 4) heard the words 7 times per trial for the 8 to 16 training trials required for habituation (J. Werker, personal communication, March 12, 2002). If amount of exposure is the critical factor, then 56 to 112 repetitions from a single talker are clearly not sufficient even if the test immediately follows this exposure.

A second possibility is that infants in Stager and Werker's (1997) study did encode the trained words in detail, but that the "mispronunciations" (e.g., *dih* for *bih*) activated the trained words sufficiently to inhibit dishabituation. This interpretation is consistent with our finding that infants were able to recognize the mispronounced words, though not as well as the correctly pronounced words. According to this account, knowledge of neighbors should actually inhibit word learning, just as neighbors inhibit word recognition in adults (e.g., Luce & Pisoni, 1998). We are currently testing this prediction in additional experiments.

Our results support models of child phonology in which early lexical representations accurately reflect surface forms. However, this does not imply that infants never misperceive words and never form inaccurate lexical representations (cf. Velleman, 1988). Errors of this sort are probably fairly common. But they are not the general case, as we have shown here. It is also possible that infants represent the beginnings of words in more detail than other parts of words, although ongoing research testing word-medial mispronunciations shows comparable effects (Swingley, 2001).

Previous experiments in which children failed to differentiate similar words undermined the relevance of studies demonstrating that from 6 to 12 months of age, infants' perception of speech sounds gradually conforms to the phonological categories of the ambient language (e.g., Werker & Tees, 1984). When children in word-learning tasks failed to treat *dak* and *gak* differently (e.g., Shvachkin, 1948/1973), it appeared that infants' sensitive phonological tuning was not effective in the context of real-world word learning (as opposed to discrimination tasks). Although the present results do not necessarily demonstrate language-specific phonological tuning, they do counter what have been the most damaging results for accounts suggesting continuity in phonetic form from infancy to early childhood. In our view, infants' learning of phonetic categories over the course of the 1st year of life is indeed relevant for the representation of infants' first words.

Acknowledgments—This work was supported by grants from the National Institute of Child Health and Human Development (NIH HD-37082) and the National Science Foundation (SBR-9421064) to R.N.A. and from the National Institutes of Health (F32-HD08307) to D.S., as well as from the Max-Planck-Gesellschaft. The authors would like to extend their thanks to Elizabeth Gramzow and Koleen McCrink-Gochal and to the students at the Infant Perception Lab at the University of Rochester for their invaluable assistance. We would also like to thank the many parents and children who made this work possible through their participation.

REFERENCES

Aslin, R.N., Jusczyk, P.W., & Pisoni, D.B. (1998). Speech and auditory processing during infancy: Constraints on and precursors to language. In D. Kuhn & R. Siegler (Eds.), *Handbook of child psychology: Vol. 2. Cognition, perception, and language* (pp. 147–254). New York: Wiley.

Brent, M.R., & Cartwright, T.A. (1996). Distributional regularity and phonotactic constraints are useful for segmentation. *Cognition*, *61*, 93–125.

Charles-Luce, J., & Luce, P.A. (1990). Similarity neighbourhoods of words in young children's lexicons. *Journal of Child Language*, *17*, 205–215.

Coady, J.A., & Aslin, R.N. (2002). *Phonological neighbourhoods in the developing lexicon*. Manuscript submitted for publication.

Fenson, L., Dale, P.S., Reznick, J.S., Bates, E., Thal, D.J., & Pethick, S.J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, *59*(5, Serial No. 242).

Ferguson, C.A., & Farwell, C.B. (1975). Words and sounds in early language acquisition. *Language*, *51*, 419–439.

Garnica, O.K. (1973). The development of phonemic speech perception. In T.E. Moore (Ed.), *Cognitive development and the acquisition of language* (pp. 215–222). New York: Academic Press.

Hayes, B. (in press). Phonological acquisition in optimality theory: The early stages. In R. Kager, J. Pater, & W. Zonneveld (Eds.), *Fixing priorities: Constraints in phonological acquisition*. Cambridge, England: Cambridge University Press.

Jusczyk, P.W. (1993). Some reflections on developmental changes in speech perception and production. *Journal of Phonetics*, *21*, 109–116.
Locke, J.L. (1988). The sound shape of early lexical representations. In M.D. Smith & J.L. Locke (Eds.), *The emergent lexicon* (pp. 3–22). San Diego, CA: Academic Press.
Luce, P.A., & Pisoni, D.B. (1998). Recognizing spoken words: The neighborhood activation model. *Ear and Hearing*, *19*, 1–36.
Menyuk, P., Menn, L., & Silber, R. (1986). Early strategies for the perception and production of words and sounds. In P. Fletcher & M. Garman (Eds.), *Language acquisition* (2nd ed., pp. 198–222). Cambridge, England: Cambridge University Press.
Metsala, J.L., & Walley, A.C. (1998). Spoken vocabulary growth and the segmental restructuring of lexical representations: Precursors to phonemic awareness and early reading ability. In J.L. Metsala & L.C. Ehri (Eds.), *Word recognition in beginning literacy* (pp. 89–120). Mahwah, NJ: Erlbaum.
Shvachkin, N.K. (1973). The development of phonemic speech perception in early childhood. In C.A. Ferguson & D.I. Slobin (Eds.), *Studies of child language development* (pp. 91–127). New York: Holt, Rinehart, and Winston. (Original work published 1948)
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.
Swingley, D. (2001). What might infants use phonemes for? In R. Smits, J. Kingston, T.M. Nearey, & R. Zondervan (Eds.), *Proceedings of the workshop on speech recognition as pattern classification* (pp. 103–108). Nijmegen, the Netherlands: Max-Planck-Institute for Psycholinguistics.
Swingley, D., & Aslin, R.N. (2000). Spoken word recognition and lexical representation in very young children. *Cognition*, *76*, 147–166.
Velleman, S.L. (1988). The role of linguistic perception in later phonological development. *Applied Psycholinguistics*, *9*, 221–236.
Waterson, N. (1971). Child phonology: A prosodic view. *Journal of Linguistics*, *7*, 179–211.
Werker, J.F., Fennell, C.T., Corcoran, K.M., & Stager, C.L. (2002). Infants' ability to learn phonetically similar words: Effects of age and vocabulary size. *Infancy*, *3*, 1–30.
Werker, J.F., & Pegg, J.E. (1992). Infant speech perception and phonological acquisition. In C.A. Ferguson, L. Menn, & C. Stoel-Gammon (Eds.), *Phonological development: Models, research, and applications* (pp. 285–311). Timonium, MD: York Press.
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.

(RECEIVED 10/4/01; ACCEPTED 12/6/01)