NIH Public Access
Author Manuscript
Child Dev. Author manuscript; available in PMC 2011 September 1.

Published in final edited form as:
Child Dev. 2010 ; 81(5): 1376–1383. doi:10.1111/j.1467-8624.2010.01479.x.

What paradox? Referential cues allow for infant use of phonetic detail in word learning

Christopher T. Fennell and
School of Psychology and Department of Linguistics, University of Ottawa

Sandra R. Waxman
Department of Psychology, Northwestern University

Abstract

Past research has uncovered a surprising paradox: although 14-month-olds have exquisite phonetic discrimination skills (e.g., distinguishing [b] from [d]), they have difficulty using phonetic detail when mapping *novel* words to objects in laboratory tasks (confusing "bin" and "din"). While some have attributed infants' difficulty to immature word learning abilities, the hypothesis presented herein is that infants are powerful word learners and this apparent difficulty occurs only when the referential status of the novel word is unclear. Across two experiments, 14-month-old infants (N = 44) used phonetic detail to map novel words to objects when conditions were conducive to word-referent mapping (clear sentential contexts and word-referent training), thus revealing no fundamental discontinuity in its use from speech perception to word learning.

In their first year of life, infants become attuned to the speech sounds of their native language. Infants' initial sensitivity to a universal set of phonetic categories is shaped by experience with the ambient language. By their first birthdays, they refine their sensitivity to those phonetic categories that carry meaning in their native language (Kuhl, et al., 2006; Werker & Tees, 1984). During this same developmental period, infants become increasingly proficient word-learners. By 12 months, they have acquired dozens of words and produce at least a handful on their own (Fenson, et al., 1994). By 14 months, infants begin to use not only the word itself, but also the linguistic context in which it is presented as a cue to meaning. They identify novel words presented as count nouns (e.g., "This is a toma") and map them specifically to objects and object categories (Waxman & Booth, 2001).

Infants' early advances in speech perception and word-learning are impressive, but recent investigations have uncovered a surprising paradox: 14-month-old infants appear unable to effectively recruit their fine sensitivity to native-language phonetic detail when mapping novel words to meaning (Pater, Stager & Werker, 2004; Stager & Werker, 1997; Werker, Fennell, Corcoran & Stager, 2002). Our goal in this paper is to demonstrate this paradox is apparent only: infants successfully recruit phonetic detail in novel word-object mappings when it is clear that the word is intended to refer to the object.

To begin, we review the evidence for this apparent paradox. We focus primarily on 14-month-olds' performance in the Switch task (Werker, Cohen, Lloyd, Casasola & Stager, 1998) because it is in this task that their failure to recruit phonetic detail in establishing word-object mappings has been revealed. Our review underscores the precision of the now-classic Switch task and its value in developmental research, but also brings to light an

Correspondence should be addressed to C.F. (fennell@uottawa.ca) or S.W. (s-waxman@northwestern.edu).

NIH-PA Author Manuscript
NIH-PA Author Manuscript
NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

important caveat: there is nothing in the design of this task that makes it clear that the novel word involves reference.

In the Switch task, infants are first introduced to a novel word – object pairing. They hear a novel word, presented repeatedly, as they observe an image of a brightly-colored novel object moving back and forth across a screen. This pairing continues until infants find it familiar, as indicated by a criterial decline in looking. In the subsequent test phase, infants witness two types of test trials, presented sequentially. On 'same' trials, the original word – object pairing is preserved. On 'switch' trials, the pairing is disrupted: the object is paired with a different word. The logic is straightforward: if infants detect this disruption, they should look longer on 'switch' than on 'same' trials. However, when the two novel words are phonetically similar (e.g., "bin" vs "din"), 14-month-olds fail to detect the mismatch (e.g., Stager & Werker, 1997).

Considerable attention has been devoted to identifying the source of 14-month-olds' surprising failure. It does not stem from a frank inability to connect novel words with novel objects in the Switch task. When the novel words are completely phonetically dissimilar ("lif" versus "neem"), 14-month-olds detect the disruption readily. Neither does their failure stem from an inability to perceive the close contrast (e.g., "b" vs "d"). When the very same contrast is presented within the context of a standard speech perception task, 14-month-olds' sensitivity is robust (Stager & Werker, 1997). If 14-month-olds can master the demands of the switch task and can also detect the relevant contrast, what accounts for their surprising difficulty? Some have proposed that infants' difficulty reflects a discontinuity between the perceptually-based *phonetic* representations that infants refine over the first year, and the more abstract *phonological* representations that are required to support word-learning (Brown & Matthews, 1997). Recent investigations cast doubt on this interpretation, however, because infants as young as 11 months are sensitive to fine phonetic distinctions between *known* words (e.g., "ball" versus "doll") (Swingley, 2005). This finding, coupled with the fact that infants successfully incorporate detailed acoustic-phonetic information in their representations of novel, as well as familiar words (Fisher, Church & Chambers, 2004), indicates that in principle, infants can bring their appreciation of phonetic detail to bear in word-learning.

Why, then, do 14-month-olds fail to recruit their finely-tuned phonetic sensitivities when mapping words to objects in the Switch task? This question is especially compelling in face of evidence that infants this age are spontaneously adding words to their lexicons in earnest (Fenson et al., 1994), and even use unstressed grammatical elements (determiners) as cues to meaning (e.g., Waxman, 1999). Thus far, efforts to address this paradoxical finding in the Switch task have appealed either to general difficulties associated with word learning (Werker & Fennell, 2004), or to a host of perceptual, attentional and memory factors (e.g., Rost & McMurray, 2009; Thiessen, 2007; Yoshida, Fennell, Swingley, & Werker , 2009).

We offer a different view. We propose that infants do indeed harness their phonetic sensitivities in word learning, but that their apparent failures to do so in previous work reflect the ambiguous referential status of the novel words. To appreciate this ambiguous status, notice that in all previous implementations of the Switch task, novel words were presented in isolation. While this ensured that the speech stimuli would be identical to those presented in standard speech perception tasks, presenting words in isolation can have adverse consequences with respect to word-learning. First, infants process isolated words *less* efficiently than words presented within phrases (Fernald & Hurtado, 2006). Second, words rarely occur in isolation in naturally-occurring speech (Aslin, Woodward, LaMendola & Bever, 1996; Brent & Siskind, 2001). Finally, and perhaps most importantly for the purposes of establishing meaning, when words do appear in isolation in naturally-occurring

NIH-PA Author Manuscript NIH-PA Author Manuscript NIH-PA Author Manuscript

speech, they are rarely names for objects. Instead, isolated words tend to be proper names ("Daddy!"), commands ("Stop!") or exclamations ("Wow!"). Importantly, infants are sensitive to this state-of-affairs. When novel words are presented within naming phrases ("Look at the blick!"), infants readily map them to the objects with which they occur. But when the very same words are presented in isolation ("Look! Blick!"), infants fail to establish a word-object mapping (Fulkerson & Waxman, 2007; Namy & Waxman, 2000).

If 14-month-old infants' failure to use phonetic detail in the Switch task is indeed a consequence of the ambiguous referential status of words, then when referential status is clarified, infants should successfully recruit their finely-tuned phonetic sensitivities to establish a word-object mapping. We designed two experiments to test this proposal. In both, we introduced 14-month-olds to the same words, objects and methods used in previous work (Pater, et al., 2004; Stager & Werker, 1997; Werker, et al., 2002), but systematically manipulated the manner in which we introduced the novel words in order to increase or decrease the clarity of the word-referent mapping.

Experiment 1

In this experiment, we embedded novel words in typical naming phrases. Our choice of naming phrases was guided by evidence that 14-month-olds interpret novel words presented as count nouns as names for objects and object categories (Booth & Waxman, 2009; Waxman & Booth, 2001).

Methods

Participants—Sixteen English-learning (>80% exposure) healthy full-term infants from greater Chicago, participated (mean = 14.7 months, range = 13.5 – 15.5 months), primarily from Caucasian middle- to upper-middle-class families recruited via mailings. An additional 11 infants were excluded due to: restlessness (10) or parental interference (1).

Stimuli—The stimuli were identical to those in previous work, except that the novel words were presented in naming phrases.

Auditory: We recorded an English-speaking female producing three novel CVC words ("bin", "din", "neem") in infant-direct speech within the context of seven different introductory phrases: Look. It's the _____. There's the ______. Do you see the _____? Look at the _____. Where's the ____? Here's the ______. I like the _____. We ensured that infants could not rely upon subtle sound differences in the introductory phrases to discriminate the target words. We spliced the introductory phrases from the "neem" stimuli just before the determiner (e.g., "*Look at* | the neem."), copied them, and spliced the determiners and nouns from the "bin" and "din" sentences onto the copies. This resulted in sentences where the introductory phrases were identical, as indicated in italics: "*Look at* the neem!"; "*Look at* the bin!"; and "*Look at* the din!". One isolated exemplar of the novel word occurred at the beginning of each trial so that infants would hear the relevant phonetic information first; another exemplar occurred at the end. "Neem" phrases were used for pre- and post-tests; "bin" and "din" phrases were used for habituation and test trials.

Visual: See Figure 1. The habituation object moved horizontally across the screen. The pre/post-test object remained stationary, while its wheel rotated.

Procedure—See Figure 1. After parent(s) completed the MacArthur Bates Communicative Development Inventory (MCDI), the infant and one caregiver were escorted to a quiet room (3.12 by 3.89 m), lit by a shaded 60W lamp situated to the left and slightly behind the infant. Visual stimuli were projected onto a screen surrounded by black cloth 1.93m from the

NIH-PA Author Manuscript
NIH-PA Author Manuscript
NIH-PA Author Manuscript

infant. Audio stimuli were delivered at 65 dB, +/− 5 dB, over two speakers located below the screen. As a masking device, caregivers listened to music over headphones. Infants' looking times were monitored via a hidden digital video-camera. The experiment was administered with the Habit X program (Cohen, Atkinson & Chaput, 2004). The experimenter, who wore headphones throughout the procedure, was blind to trial type. Each 20 second trial began when the infant fixated on an onscreen attention-getter. To begin, infants were presented with a pretest trial, involving a waterwheel object and the "neem" phrases. The habituation phase commenced immediately thereafter and ended when the infant's looking time across a two-trial block decreased to 65% of the longest block, or after 24 habituation trials (mean length: 10.55 trials, 95 tokens; *SD* = 6.22, 55.98). The word used in habituation phrases (bin, din) and the presentation order of the test trials were counterbalanced. A post-test trial, using dissimilar stimuli from habituation (the waterwheel – "neem" pairing), Infants recovered from the last habituation block to this post-test in both Experiments 1 and 2 (all p values < .01), ensuring that infants were not fatigued or generally disinterested in the task. Using a frame-by-frame analysis (1 frame = 33.33 msec), two experienced coders, blind to condition assignment, scored infants' looking times (*r* > .95 in Experiments 1 and 2).

Results and Discussion

When the novel words were embedded within naming phrases, 14-month-olds successfully harnessed their finely-tuned phonetic sensitivities to map that word to its intended referent. See Figure 2. Infants looked reliably longer on switch (*M* = 11.67 s, *SD* = 4.56) than on same (*M* = 9.46 s, *SD* = 3.88) trials [$t(15) = 2.36$, $p = .03$, $d = 0.52$].

Infants' success in this task is striking. In contrast to infants hearing isolated words, these infants had to parse the novel words from the continuous speech stream. Their success, even in the face of this more crowded perceptual space, suggests that embedding the novel words in phrases did indeed clarify their referential status for the infants. But could infants' success be attributed to something else? In continuous speech, each phoneme (e.g., "b") is influenced by those surrounding it; the transitions between phonemes provide co-articulatory cues, to which infants as young as five months show sensitivity (Fowler, Best & McRoberts, 1990). Perhaps by embedding novel words in phrases, we provided infants in Experiment 1 with co-articulatory cues (transitions between determiners and novel words) that were unavailable to infants hearing isolated words in previous versions of the Switch task. To discover whether infants' success in Experiment 1 could be attributed to this additional perceptual information or to the referential status of the novel words, we designed a second experiment.

Experiment 2

Our goal was to present the novel words in isolation, as in previous versions of the Switch task, but to maintain their referential clarity. To achieve this, we took advantage of a compelling finding: if infants first have an opportunity to observe a series of familiar objects (e.g., car, kitty), each paired with its familiar basic level name, presented in isolation (e.g., "Car!" "Kitty!"), they subsequently map *novel* words, also presented in isolation, to novel objects. But if the very same familiar objects are initially paired with familiar exclamations (e.g., "Wow!" "Whee!"), infants fail to establish consistent mappings (Namy & Waxman, 2000).

Building upon this insight, we introduced a brief training period, in which infants were introduced to three familiar objects (car, shoe, cat). Infants were randomly assigned to one of two training conditions. In the Name-training condition, each training object (e.g., car) was paired with its familiar basic-level object name, presented in isolation (e.g., "Car!"). In

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

the Exclaim-training condition, each training object was paired with a familiar exclamation (e.g., “Wow!”). We then observed infants’ performance in the Switch task, with novel words presented in isolation.

If infants’ success in Experiment 1 can be attributed to perceptual factors (e.g., coarticulatory cues), then infants in both training conditions should fail to map the novel words, now presented in isolation, to the accompanying object in the subsequent Switch task. But if instead, infants’ success in Experiment 1 is a consequence of increased referential clarity, then performance in the Name- and Exclaim-training conditions should differ. We predict that the Name-training manipulation will establish that isolated words can refer to objects in the context of this task, and that as a result, infants in this condition will map the novel word in all its detail to the accompanying object. In contrast, although infants in the Exclaim-training condition also hear familiar words, and although these words are themselves attention-enhancing (e.g., “Wow”), they do not refer specifically to objects. Therefore, we predict that infants in the Exclaim-training will not infer that isolated words function as names for objects in this task, and as a result, will not map the novel word to the accompanying object in the subsequent Switch task.

Method

Participants—Twenty-eight English-learning, healthy, full-term infants (mean = 14.37 months, range = 13.55 – 15.49 months) from greater Chicago participated. All infants comprehended the basic-level name for at least one training object, as measured by the MCDI. An additional 16 infants were excluded due to restlessness (8), comprehending none of the training object labels (5), technical error (1), or parental interference (2). There were no differences between the two conditions on any vocabulary measure (See Table 1).

Stimuli—The novel words, identical to those in Experiment 1, were now presented in isolation. The training phase included moving images of a car, cat and shoe with their basic-level names (“car”, “kitty”, “shoe”) or with familiar exclamations (“whee”, “wow”, “yay”).

Procedure—This was identical to Experiment 1 with two exceptions (see Figure 1). First, in lieu of the pretest, we introduced a training phase; infants saw three familiar objects, presented sequentially, each paired with either its appropriate basic-level name or an exclamation. The order in which these training trials were presented was counterbalanced across infants within training conditions. Second, because novel words were presented in isolation, habituation trials were reduced from 20 to 14 seconds in duration (similar to Stager and Werker, 1997).

Results and discussion

Even in the absence of any co-articulatory cues, infants in the Name-training condition successfully established word-object mappings; those in the Exclaim-training condition did not. A 2 (test trial: same vs. switch) by 2 (condition: Name- vs. Exclaim-training) mixed ANOVA revealed no main effects [trial: $F(1,26) = 2.43$, $p = .13$, partial $\eta^2 = 0.08$; condition: $F(1,26) = 1.06$, $p = .31$, partial $\eta^2 = 0.04$]. A significant trial by condition interaction [$F(1,26) = 5.02$, $p = .03$, partial $\eta^2 = 0.16$] revealed the predicted outcome (Figure 2). Infants in the Name-training condition established a word-object pair, looking reliably longer on ‘switch’ ($M = 8.92$ s, $SD = 2.26$) than on ‘same’ ($M = 6.97$ s, $SD = 1.87$) test trials [$t(15) = 2.53$, $p = .02$, $d = 0.94$]. Thus, infants’ use of fine phonetic detail in Experiment 1 cannot be attributed to low-level perceptual factors alone. In contrast, infants in the Exclaim-training condition failed to detect the switch [$t(15) = 0.52$, $p = .61$, $d = 0.13$].

NIH-PA Author Manuscript
NIH-PA Author Manuscript
NIH-PA Author Manuscript

The difference between these two conditions cannot be attributed to selective adaptation, a phenomenon in which repeated exposure to one endpoint of a phonetic continuum (e.g., [b]) leads to a perceptual bias favouring the other endpoint (e.g., [d]). We tallied the number of habituation tokens ("bin" or "din"; 7 per trial) presented to infants in each of the conditions and found no significant difference [$t(26) = -1.59$, $p = .12$, $d = -.60$; name: $M = 51$, $SD = 24.32$; exclaim: $M = 73$, $SD = 45.67$]. Further, there was no correlation between this measure and infants' increased looking time to 'switch' [$r(26) = 0.09$, $p = .66$]. Moreover, an analysis of infants' vocabularies provided additional evidence that referential, and not perceptual, factors, accounted for infants' success. We tallied the number of training words comprehended by each infant (0 to 3), including those 5 infants who were excluded from the above analyses because they comprehended none of the training objet labels. This measure was correlated with success in the Name-training condition, where comprehension was crucial to understanding that isolated words could refer to the objects, but not the Exclaim-training condition [name: $r(16) = .59$, $p = .01$; exclaim: $r(13) = -.24$, $p = .38$].

General Discussion

Together, these experiments constitute strong support for the hypothesis that 14-month-old infants can indeed recruit their finely-honed sensitivities to phonetic detail in the task of word learning, and do so effectively when the referential status of the to-be-learned novel word is clear. When novel words are presented in an unambiguously referential context (naming phrases in Experiment 1; Name-training in Experiment 2), 14-month-olds recruit their perceptual sensitivities to establish precise word-object mappings. When the referential status of the novel word remains ambiguous (as in the original Switch tasks; Experiment 2: Exclaim-training), infants fail.

Moreover, these results take us one step further, demonstrating that infants have multiple ways to identify referential status. In Experiment 1, where the novel words were embedded in naming phrases, infants took advantage of syntactic cues to establish their referential status. In Experiment 2, where no syntactic information was provided, infants capitalized on pragmatic cues to establish referential status (Namy & Waxman, 2000). Infants in the Name-training condition, who were provided with pragmatic evidence that words presented alone could indeed be names for objects, were able to exploit this evidence to map novel words to objects in the subsequent Switch task, and to use fine phonetic detail in doing so. Importantly, infants' persistent failure to do so in the Exclaim-training condition documents that simply presenting infants with familiar objects paired with familiar attention-directing words is not sufficient. Instead, what 14-month-old infants require to establish a word-object mapping is a reason to expect that the word is meant to refer. Although it is beyond the scope of the current paper to consider fully the factors involved in infants' emerging understanding of reference (see Waxman & Gelman, 2009), it is clear that 14-month-old infants are sensitive to referential cues, that these support infants' establishment of word-object mappings, and permit infants to bring their finely-honed phonetic sensitivities into play in the process of word-learning. Thus, bringing in the notion of reference - a fundamental feature of human language – helps to resolve what was previously seen as a paradox in infant word-learning.

Our proposal concerning the essential role of referential status also brings together a series of otherwise apparently unrelated recent findings under one umbrella, rather than appealing to a diverse array of methodological and perceptual explanations. For example, when 14-month-olds are introduced to a novel object in the context of a focused, social interaction with an adult, they attend successfully to fine phonetic detail when establishing word-object mappings (Mani & Plunkett, 2008). We suspect that this animated social interaction, focusing specifically on an object for which infants had no known name, served to increase

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

their interest in discovering its name. Similarly, when 14-month-olds are permitted to play with an unnamed novel object in their homes in the weeks preceding their lab visit, they attended to phonetic detail when mapping a novel word to that object in the lab during the Switch task (Fennell, 2004, submitted). Here, we suspect that infants' prolonged engagement with an unnamed toy augmented their interest in discovering its name when provided with candidates in the laboratory during the Switch task. Evidence from another recent report fits well with our focus on reference and meaning. When novel words were produced by a range of *different* speakers during habituation, 14-month-olds successfully detected changes in phonetic detail (Rost & McMurray, 2009). Rost and McMurray attributed infants' success to perceptual factors, hypothesizing that exposure to a range of exemplars supported infants' ability to build stable phonetic categories. We concur, but point out that this task likely offered infants additional referential information as well. After all, when a range of different speakers consistently applies the very same word to a novel object, this social convergence signals that that word is the name of that object.

Another recent report indicates that clarifying referential status in the testing phase also aids infants. Yoshida, et al. (2009) presented a version of the Switch task in which 14-month-old infants were introduced to two similar-sounding words ("bin" and "din), each paired with a unique novel object. At test, infants saw both novel objects simultaneously, but heard only one of the two novel words. To succeed, infants had to map each of two similar-sounding words presented during habituation to its associated object, and to represent these words with sufficient phonetic detail to direct their attention to the correct object at test. Surprisingly, 14-month-olds succeeded. Yoshida et al. argued that presenting the two novel objects simultaneously at test reduced the memory demands of the task, leading to infants' success. We take no issue with this interpretation, but point to another design feature that was likely instrumental. To familiarize them with the forced-choice nature of this task, infants viewed 'filler trials' before viewing the test trials themselves. The structure of the filler trials was identical to that of the test trials, with one important exception: filler trials included objects and words *familiar* to the infants (e.g., they saw a car and shoe side-by-side and heard "car"). In our view, these filler trials were instrumental not only because they oriented infants to the structure of the test trials, but also because the inclusion of familiar words and objects, (like the Name-training trails of Experiment 2) served to establish the referential status of novel words.

Each of these recent demonstrations, considered on its own, sheds light on a distinct factor mediating infants' performance. But invoking the notion of referential status provides a more integrative account for infants' patterns of successes and failures. In our view, these recent findings converge to support the proposal that infants use social, linguistic and pragmatic information as windows into the referential status of a novel word, and that once this status is assured, they recruit their sensitivity to fine phonetic detail to map that word to its intended referent.

Although we have focused expressly on the essential role of referential status in word-learning, we acknowledge the importance of other elements as well, chief among them the perceptual factors. Recent evidence establishing the power of perceptual cues comes from Thiessen (2007). Before participating in a Switch task, infants in this experiment were exposed to a training period in which the novel words were presented under variable phonetic contexts. This purely perceptual boost in training supported infants' subsequent use of phonetic detail in the Switch task, suggesting that when the phonetic distinction is sufficiently robust (as with the completely distinct words "lif" and "neem"), 14-month-olds succeed (Werker, et al., 1998). Infants' success in Thiessen (2007) and Werker, et al. (1998) reveals that, even in the absence of referential clarity, infants' attention to phonetic detail can be augmented by perceptual means. Importantly, the results of the current experiments

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

reveal that the corollary is also true: even in the absence of any added perceptual information, infants' attention to phonetic detail is boosted when the referential status of the word is made clear. In future work, it will be important to discover how various factors (perceptual, syntactic, social and pragmatic) come together in the service of word-learning.

The current work provides a resolution to what has been seen as a paradox. It reveals that there is considerable continuity in the phonetic representations that infants refine over the first year of life and the lexical representations they establish thereafter. It also fortifies the view that infants (like adults) take into consideration more than associations alone when establishing word-meaning (Gogate & Bahrick, 1998; Waxman & Lidz, 2006). In every version of the Switch task, the presence of a novel word is correlated perfectly with the presence of a novel object. Yet this correlation alone, however perfect, is not sufficient to support the establishment of a strong enough word-object mapping to reveal infants' use of fine phonetic detail. We therefore conclude that when mapping words to meaning, infants' recruit both their sensitivity to fine phonetic detail as well as their sensitivity to the distinct referential status of words.

Acknowledgments

We thank J. Werker and E. Leddon for discussions, A. Weisleder and L. Plotkin for testing, and the participating parents and infants. NIH R01-HD30410 (S.W.) and a SSHRC Postdoctoral Fellowship (C.F.) provided research support.

References

Aslin, RN.; Woodward, JZ.; LaMendola, NP.; Bever, TG. Models of word segmentation in fluent maternal speech to infants. In: Morgan, JL.; Demuth, K., editors. Signal to Syntax. Mahwah, NJ: LEA; 1996. p. 117-134.

Booth AE, Waxman SR. A horse of a different color: Specifying with precision infants' mappings of novel nouns and adjectives. Child Development. 2009

Brent MR, Siskind JM. The role of exposure to isolated words in early vocabulary development. Cognition. 2001; 81:B33–B44. [PubMed: 11376642]

Brown, C.; Matthews, J. The role of feature geometry in the development of phonemic contrasts. In: Hannahs, SJ.; Young-Scholten, M., editors. Focus on Phonological Acquisition. Amsterdam: John Benjamins; 1997. p. 67-112.

Cohen, LB.; Atkinson, DJ.; Chaput, HH. Habit X: A new program for obtaining and organizing data in infant perception and cognition studies (Version 1.0). Austin: University of Texas; 2004.

Fenson L, Dale PS, Reznick JS, Bates E, Thal DJ, Pethick SJ. Variability in early communicative development. Monographs of the Society for Research in Child Development. 1994; 59:1 – 173. [PubMed: 7845413]

Fennell, CT. Unpublished doctoral dissertation. University of British Columbia; 2004. Infant attention to phonetic detail in word forms: Knowledge and familiarity effects.

Fennell CT. Object knowledge facilitates use of phonetic detail in novel words. Cognition. submitted.

Fernald A, Hurtado N. Names in frames: Infants interpret words in sentence frames faster than words in isolation. Developmental Science. 2006; 9:F33–F40. [PubMed: 16669790]

Fisher, C.; Church, B.; Chambers, KE. Learning to identify spoken words. In: Hall, DG.; Waxman, SR., editors. Weaving a lexicon. Cambridge, MA: MIT Press; 2004. p. 3-40.

Fowler CF, Best CT, McRoberts GW. Young infants' perception of liquid coarticulatory influences on following stop consonants. Perception & Psychophysics. 1990; 48:559–570. [PubMed: 2270188]

Fulkerson AL, Waxman SR. Words (but not tones) facilitate object categorization: Evidence from 6- and 12-month-olds. Cognition. 2007; 105:218–228. [PubMed: 17064677]

Gogate LJ, Bahrick LE. Intersensory redundancy facilitates learning of arbitrary relations between vowel sounds and objects in seven-month-old infants. Journal of Experimental Child Psychology. 1998; 69:133–149. [PubMed: 9637756]

NIH-PA Author Manuscript
NIH-PA Author Manuscript
NIH-PA Author Manuscript

Kuhl PK, Stevens E, Hayashi A, Deguchi T, Kiritani S, Iverson P. Infants show a facilitation effect for native language perception between 6 and 12 months. Developmental Science. 2006; 9:F1 – F9. [PubMed: 16445386]

Mani N, Plunkett K. 14-month-olds pay attention to vowels in novel words'. Developmental Science. 2008; 11:53–59. [PubMed: 18171367]

Namy LL, Waxman SR. Naming and exclaiming: Infants' sensitivity to naming contexts. Journal of Cognition and Development. 2000; 1:405–428.

Pater J, Stager CL, Werker JF. The lexical acquisition of phonological contrasts. Language. 2004; 80:361–379.

Rost GC, McMurray B. Speaker variability augments phonological processing in early word learning. Developmental Science. 2009; 12:339–349. [PubMed: 19143806]

Stager CL, Werker JF. Infants listen for more phonetic detail in speech perception than in word-learning tasks. Nature. 1997; 388:381–382. [PubMed: 9237755]

Swingley D. 11-month-olds' knowledge of how familiar words sound. Developmental Science. 2005; 8:432–443. [PubMed: 16048516]

Thiessen ED. The effect of distributional information on children's use of phonemic contrasts. Journal of Memory and Language. 2007; 56:16–34.

Waxman SR. Specifying the scope of 13-month-olds' expectations for novel words. Cognition. 1999; 70:B35–B50. [PubMed: 10384739]

Waxman SR, Booth AE. Seeing pink elephants: Fourteen-month-olds' interpretations of novel nouns and adjectives. Cognitive Psychology. 2001; 43:217–242. [PubMed: 11689022]

Waxman, SR.; Lidz, J. Early word learning. In: Kuhn, D.; Siegler, R., editors. Handbook of Child Psychology. 6. Vol. 2. Hoboken, NJ: Wiley; 2006. p. 299-335.

Werker JF, Cohen LB, Lloyd VL, Casasola M, Stager CL. Acquisition of word-object associations by 14-month old infants. Developmental Psychology. 1998; 34:1289–1309. [PubMed: 9823513]

Werker, JF.; Fennell, CT. Listening to sounds versus listening to words: Early steps in word learning. In: Hall, DG.; Waxman, S., editors. Weaving a Lexicon. Cambridge: MIT Press; 2004. p. 79-109.

Werker JF, Fennell CT, Corcoran KM, Stager CL. Infants' ability to learn phonetically similar words: Effects of age and vocabulary. Infancy. 2002; 3:1–30.

Werker JF, Tees RC. Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. Infant Behavior and Development. 1984; 7:49–63.

Yoshida K, Fennell CT, Swingley D, Werker JF. Fourteen-month-old infants learn similar sounding words. Developmental Science. 2009

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

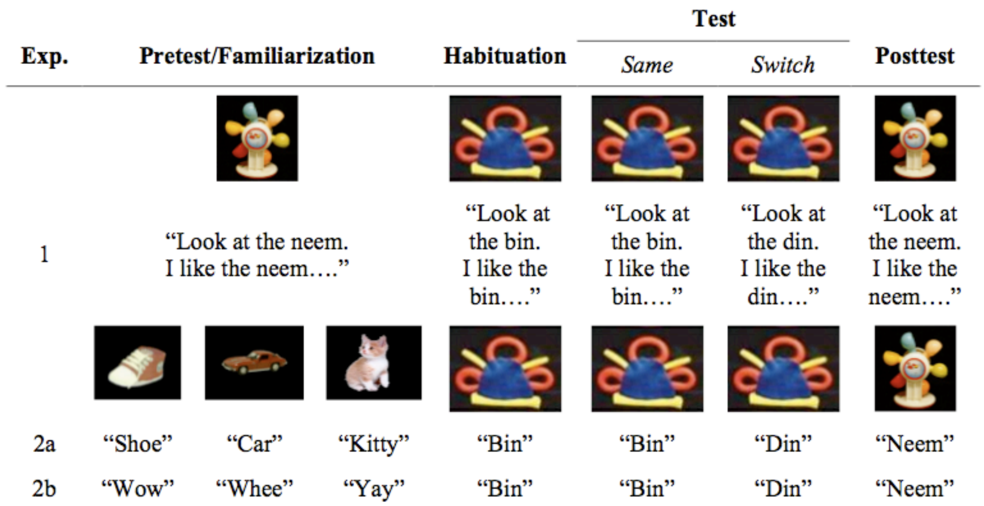

Figure 1.
Experimental design and stimuli.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

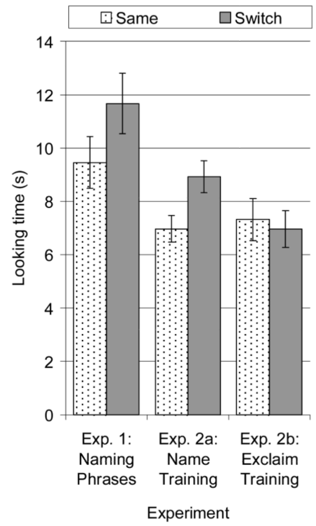

Figure 2.
Mean looking times (and standard error) for 'same' and 'switch' trials across conditions.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 1

Experiment 2: Vocabulary Data

	Condition			
Vocabulary Measures	**Name**	**Exclaim**	**t(26)**	***p***
Vocabulary: Comprehension	153.64	127.29	0.96	0.35
Vocabulary: Production	15.00	17.86	0.45	0.66
Training words comprehended	2.50	2.64	0.54	0.59
Training words produced	0.43	0.50	0.29	0.77