PHONETIC SIMILARITY INFLUENCES LEARNING WORD-OBJECT ASSOCIATIONS IN 14-MONTH-OLD INFANTS

by

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Abstract-- This series of studies investigated the ability of 14-month-old infants to differentiate similar-sounding words in a word-object association task. Despite the remarkable speech perception abilities previously demonstrated in young infants, studies of word learning in older infants indicate they have difficulty learning similar-sounding words. This evidence suggests that infants may not be using their remarkable speech-perception abilities as they move into word learning. The purpose of my research was to test for evidence of the ability to form word-object associations for similar sounding words, at an early stage of word learning.

Previous research has demonstrated infants are able to learn word-object associations for words that do not sound similar (Werker, Cohen, & Lloyd, 1995). The present studies used a similar design, in which infants are habituated to either one or two word-object pairings and are then tested with a pairing where either the object or the label is switched from those presented in the habituation phase. Across a series of three experiments it was demonstrated that infants notice when the switch that occurs is a switch in the object, but not when the switch is a switch in the label. This suggests older infants do have difficulty learning phonetically similar word-object associations.

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INTRODUCTION

The difficulties young children appear to have in the comprehension and production of phonetically-similar words is puzzling when the speech-perception abilities of younger infants are considered. Very young infants have speech-discrimination abilities that appear more sensitive than those of adults (see Werker, 1991 for a review), suggesting that learning phonetically-similar words should not pose a problem for infants. The difficulty young children experience with phonetically-similar words suggests that they may not be using all of their fine speech-perception skills to help them acquire language. This apparent discrepancy between the abilities of infants and of young children suggests that the difficulty for young children may come as they move into mapping the sounds they hear onto meaning. I will review infant speech-perception abilities and young children's early word learning in order to begin to understand this lack of isomorphism.

Infant Speech Perception

When we examine the remarkable speech-perception abilities of infants, it appears the infants are being tuned for the task of word learning, i.e., mapping sound to meaning. Infants are quickly able to process and parse the speech stream before the end of the first year of life, demonstrating sensitivity to clause boundaries (Jusczyk & Kemler Nelson, in press), phrase boundaries (Jusczyk et al., 1992), and word boundaries (Christophe, Dupoux, Bertonicini, & Mehler, 1994). In addition to speech segmenting skills, it appears infants rapidly become tuned to their native language within the first year of life (e.g. Werker & Tees, 1984). Infants are initially able to discriminate phonemes (speech sounds used to contrast meaning), including those not used in the native language (Aslin et al., 1981; Streeter, 1976; Trehub, 1976;

Werker, Gilbert, Humphrey, & Tees, 1981), but by 12 months of age appear to discriminate only native contrasts (e.g., Werker & Tees, 1984; Werker & Lalonde, 1988; Polka & Werker, 1994; Best et al., in press). Infants show sensitivity to language-specific timing features (Bijeljac-Babic, Bertoncini, & Mehler, 1993), stress patterns (Jusczyk, Cutler, & Redanz, 1993), and phonotactic constraints (Jusczyk, Luce, & Charles-Luce, 1994) within the first year of life.

Infants also appear to encode detailed information about the words spoken around them. Jusczyk and Aslin (in press) found that infants as young as 7 1/2 months of age appear to recognize words they have heard before. Jusczyk and Aslin did not find evidence of this ability in 6-month-old infants. To determine how much phonetic detail infants are encoding when they hear these words, Jusczyk and Aslin tested infants using training and test stimuli that differed in only a single phonetic feature of the initial consonant. Infants did not identify the test stimuli as equivalent to the training stimuli, which suggests they were encoding a detailed representation that included the initial consonant (Jusczyk & Aslin, in press).

Based on these findings in infant speech-perception, we might predict that infants could use fine-grained perceptual abilities in word learning, and should be able to learn even similar-sounding words. However, there are a number of reasons to suspect that infant perceptual sensitivities may not match the abilities infants are able to use functionally in acquiring language.

This suspicion is motivated in part by the observation that the paradigms used and the stimuli selected for testing infants in basic speech-perception tasks are less complex than what infants encounter in the real world. Often, the stimuli used in speech-perception experiments are controlled so they differ on only the acoustic/phonetic dimension being

tested. This is not the condition under which the infant will encounter spoken language in the real world. Also, in infant experiments the test stimuli are often presented in an artificial manner. For example, they may be presented without any background noise, as when infants are tested in a sound-attenuated booth. Or, stimuli may be presented without the variability that might be present in a natural setting, and in isolated form, with no word boundaries that need to be determined. Many of the studies allow the infant to habituate to a single stimulus, creating a level of familiarization not available to the infant in a real-life word-learning situation. It could be that under natural conditions the increased attentional demands of the natural stimuli lead infants to extract less detailed information from the speech stream than their perceptual capacities allow (e.g., Jusczyk, 1985, 1986).

This research can be interpreted as indicating we must be careful in predicting the speech-perception abilities infants are able to use in word learning. These abilities have been demonstrated only under laboratory conditions, and may not reflect the functional abilities used by the infants in a natural setting. While perceptual abilities show considerable tuning to native-language properties towards the end of the first year of life, roughly the same time as children are thought to acquire their first words (e.g., Fenson et al., 1994), the perceptual abilities may not be fully applied in a word-learning task.

Early word learning in young children

An examination of the early word-learning literature suggests young children are not using a fine-grained analysis of the speech stream around them. Early word learning is one of the first tests of the functional utility of infant speech-perception abilities. These word-learning abilities have been

assessed using comprehension probes as well as production data. Studies of early word learning that examine comprehension indicate that typically comprehension vocabulary exceeds productive vocabulary and thus may be a more accurate representation of the child's word-learning abilities (e.g., Benedict, 1979; Chapman, Kay-Raining Bird, & Schwartz, 1990). Therefore, I will review only the literature on comprehension here.[1]

The nature of the lexical representation used during early word learning has not been fully studied. Knowledge of the detail of the representations used in early word learning will aid in an understanding of whether young children are using their fine speech-perception skills in word learning. The best way to examine the nature of the representation is to test young children's ability to learn and differentiate words that sound very similar. If they are encoding detailed representations, they should be able to differentiate similar-sounding words. If they are not encoding detailed representations, they should treat such words as the same. If they are not encoding complete representations, they might have more difficulty with some discriminations than with others, depending on the position of the contrastive information.

The level of detail represented can be examined by testing phonemic perception in infants. Phonemes, sounds that contrast meaning, are determined separately for each language (e.g., /k/ and /g/ are phonemes because the words 'coat' and 'goat' mean different things). The phonemic inventory of a language is determined by the minimal pairs that are present

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[1] I will exclude most studies that examine children's productions, as there exist so many alternative explanations when we do <u>not</u> find evidence that a child can produce a word. For example, the child may be tired, shy, or limited by some articulatory or cognitive demand. Studies that rely on production data are often a problematic index because many rely on parental report, which is fraught with possible biases. I will therefore not discuss data looking at production in detail. There are, however, a few important findings that should be addressed.

in that language. A minimal pair is defined as a pair of words that differ by only a single sound in the same position (e.g. goat-coat). The sounds that differ in a minimal pair are considered phonemic for that language.

In studying phonemic perception we are interested in determining how the child recognizes and classifies the oppositions being studied. For infants to make a phonemic distinction successfully they must not only hear the sounds as distinct, but also recognize the sounds discriminated as indicative of a semantic distinction.

There has been very little research to date on the abilities of young children to discriminate words that differ by only a single phoneme. Evidence of learning phonetically similar words has been tested only in older children, at an age significantly past early word learning (Barton, 1978; Garnica, 1973; Schvachkin, 1973). Many of the studies that have been done were motivated not by the question of whether learning similar-sounding words is difficult for young children, but rather to test Jakobson's (1968) hypothesis of a universal order of acquisition of phones (the sounds of a language) within a language (e.g., Garnica, 1973; Schvachkin, 1973). Nevertheless, we can examine this literature for information related to the questions of interest in this thesis. Work by Schvachkin (1973) and later by others (Barton, 1978; Garnica, 1973) on this topic reveals that young children seem to have difficulty when learning words that sound similar.

The results of Schvachkin's (1973) experiments can be used to examine whether young children 1 to 2 years of age are processing the entire word when they perceive differences between words. He tested the child using minimal pairs, where the position of the contrastive phone was varied.

Schvachkin tested his subjects in a number of steps. He first taught young children two nonsense words that differed by more than one phoneme

as labels for novel objects. After he determined that they had learned the associations, he asked them to carry out various tasks using these two nonsense words. On the next day he taught the children a third nonsense word that contained a minimal opposition to one of the earlier taught words. The next step was to ask the children to respond to the newest word when put in contrast with the second (non-minimal pair) taught word. Finally, he would place all three objects with nonsense labels in front of the children and test for discrimination. To avoid context-dependent performance he administered 6 different tests to each child, where the child was thought to perceive the minimal-pair contrast if she could perform successfully in at least three of the tests. The 6 tests were: pointing, passing the object, placing the object, finding the object, operation of one object relative to another, and substitution of objects. While excellent in its design, the empirical contribution of Schvachkin's work has been minimized by a lack of information about his procedure, such as the number of test trials.

Schvachkin used nonsense monosyllabic CVC (C for consonant, V for vowel) or VC stimuli. He tested discrimination of: (1) the vowels in CVC, when the consonants were the same (CV_1C vs. CV_2C), (2) the initial consonants when the vowels and final consonants were the same (C_1VC_3 vs. C_2VC_3), and (3) C_1VC_2 vs. VC_2 where the vowel and final consonants were the same. He did not vary the final consonants or test young children using multisyllabic words. On the basis of his work Schvachkin concluded young children are able to discriminate all the consonantal phonemes he tested in word-initial position before age 2;0 (see Table 1 for a list of the consonants young children can discriminate).

Schvachkin's study is inconclusive for a number of reasons. He used an extremely complicated and time-consuming procedure that may be prone

to fatigue effects on the part of the child, or skew his results because of the non-speech cognitive demands placed upon the young children. There also exists the possibility of experimenter bias, as the experimenter was not blind to the condition being tested.

Studies by Garnica (1973) followed up on the work of Schvachkin. Garnica tested English children to determine if their order of phone acquisition matched that determined by Schvachkin for Russian children. If the orders were the same, this finding would support Jakobson's (1968) hypothesis of a universal order of phone acquisition. She tested infants and children ages 1;5 to 3;5. She first conducted a pilot study with 8 English-speaking children. In the pilot study Garnica taught children puppet names which differed in the initial consonant ("Mr. C_1VC" vs. "Mr. C_2VC"), comprising a minimal pair. The children played with each of the objects separately, and carried out a task with each object. The child was then presented with both objects and was asked to perform a task with one of the pair. Although the data were limited by the number of children and the variety of stimuli used, Garnica determined an order of acquisition of phonemes which she tested in her next study. In her second study Garnica tested 15 infants aged 1;5 to 1;10, using the technique developed in her previous study. In this study a different order of acquisition was found. On the basis of these two preliminary studies, Garnica concludes that there is no universal order of acquisition, but rather a general trend in children's phonological acquisition (1973) (see Table 2 for her resulting trend).

Garnica's studies are prone to many of the criticisms leveled at the work done by Schvachkin. Barton (1978) discusses many of the problems with the Schvachkin-Garnica procedure. These include small sample sizes and procedures which were too difficult for the children. The procedures

were too difficult primarily because the children may not have been adequately familiarized with the stimuli before testing. Underfamiliarization may have resulted in more conservative estimates of the onset of phoneme discrimination. Barton (1978) also notes that the procedure is not designed to keep the experimenter blind to the stimuli being tested, and further that there is no assessment of reliability between experimenter judgments. Barton (1978) is critical of the Schvachkin and Garnica studies, as in the scoring method discrimination is treated as a discrete process where there is no possibility of gradual acquisition, such that it is assumed that all members of a phonemic class are acquired simultaneously. Barton (1978) is also critical of the error rate reported by Garnica, claiming it is artificially low, due to inappropriate statistical treatment of the data.

Eilers and Oller (1976) examined discrimination of stimuli in 8 pairs, where one member of the pair was a familiar word, and the other was a similar-sounding unfamiliar word. In their procedure the child was first familiarized with a set of toys, and was encouraged to learn the names of the toys well. The experimental task was then to retrieve a reward hidden under one of two toys. Eilers and Oller reported that infants aged 1;10 to 2;2 were able to perform a discrimination task if the words differed in 2 phonetic features, but some discriminations were more difficult or impossible for the children (e.g., [fIʃ]-[θIʃ] and [mʌki]-[mʌŋki]). Eilers and Oller do not report whether it mattered how familiar children were with the "familiar" word.

Barton (1978) designed a series of studies in which he attempted to eliminate the problems he observed in other studies. He looked at minimal-pair discrimination using real words in children aged 2;3 to 2;11. Children were asked to match the word they heard to the appropriate picture referent. He tested 20 minimal pairs and found that infants were able to make most

discriminations. He attributed any failures to discriminate within a pair to cases where the infants had not properly learned the words.

In his main procedure he responded to a number of the criticisms of the Schvachkin-Garnica procedure. By doing some preliminary testing Barton was able to determine which tasks were suitable for the children, and to determine the amount of time necessary to familiarize a child with a word. He used prerecorded stimuli in an attempt to eliminate bias created in the live presentation of the stimuli by the experimenter. However, a problem remains in that the experimenter is able to hear the presentation of the stimuli, which could affect the nature of the interaction with the child.

In a second study examining the abilities of infants aged 1;8 to 2;0 years. Barton (1978)found children were able to discriminate /b-p/ ('bear', 'pear') and /g-k/ ('goat', 'coat'). These were contrasts which were reported by Garnica and Schvachkin to be difficult for children (see Tables 1 and 2). He attempted to test children at ages younger than 1;8, but found the task was too difficult.

The results of these studies of phonemic perception by Barton and others do not allow us to conclude whether very young children are able to discriminate phonetically similar words. The paradigms used to test children on phonemic discrimination require the children to show discrimination of words they may have already been exposed to, and their performance may simply reflect familiarity. In addition, many of the tasks may be difficult for the young child in that they require referential use of the named objects, a task which may require very advanced comprehension and general cognitive skills. Thus, some of the limits in performance may be unrelated to phonemic perception.

Werker (as discussed in Werker & Pegg, 1992) examined comprehension of phonetically similar words in younger children. She used

a preferential looking task which eliminates many of the task problems reported for previous studies. The experiments were designed to test when young children are able to distinguish a real word label from a minimally different nonsense word. Children in the experimental group were presented either with a real "word" or with a minimally different "nonsense" word embedded in carrier phrases. Children were simultaneously shown images of two pictures, one that matched the noun in the carrier phrase and one that showed a picture of a novel object. On half the trials the "real" word was presented, and on half the trials, the "nonsense" word. Successful performance entailed longer looking to the labeled object when paired with the "real" word, than when paired with the minimally different "nonsense" word. Children of all ages performed at chance, looking equally long to the real object and the novel object, whether presented with a matching or non-matching label. In a subsequent study subjects were presented with pairs that were comprised of two real words that were phonetically dissimilar, which resulted in significant differences in looking time. The data indicate difficulty in discriminating a real word from a minimally different nonword, but the experiment design confounds word familiarity and phonetic similarity.

Another experiment was conducted using a different procedure to address the confounding of word familiarity and phonetic similarity (Werker & Baldwin, 1991). In this procedure infants were shown one picture on one monitor. They were tested in 4 trials, using different labels in carrier phrases. The 4 labels were: correct real word (referring to the picture on the monitor), phonetically similar nonsense word (forming a minimal pair with the correct label), a phonetically dissimilar real word, and a phonetically dissimilar nonsense word. Looking time during presentation of each of the words was recorded. Using this procedure, Werker and Baldwin (1991) found that by 19

months, but not at younger ages, children looked longer at the object when listening to the word that matched it than when presented with any of the other 3 words. These results suggest that children younger than 19 months are not using fine phonetic detail in word learning. It should be noted, however, that this effect – even with 19 month olds – was found for only one contrast (/b/ vs. /d/). A second group of 19-month-olds tested with the /k/-/g/ distinction failed to show the same pattern.

CURRENT STUDY

The research findings discussed above suggest that despite infants' acute speech-perception sensitivities, young children may have trouble learning similar-sounding words. Indeed, the studies relevant to the task of phonemic perception that have been conducted with older infants indicate that the infants are no longer using all the perceptual sensitivities demonstrated in younger infants. However, the tests in the studies with older infants may be difficult for the young children not because of difficulty with phonetically similar words, but rather because of demands of the task. Previous studies often targeted children who had been learning words for a number of months, and in many cases were producing a significant number of words as well. It may be that these children demonstrated difficulty with learning phonetically similar words for reasons related to other cognitive demands, but may be able to demonstrate this skill in a simple task which looks at early word-object association.

In order to investigate whether young children are able to bring to bear perceptual-sensitivities in a task as similar as possible to word learning we need a task which is appropriate for a very early word learner. An ideal task would test more than perceptual discrimination, but would not require as

much cognitive involvement from the child as a referential word-learning task. We chose to use a habituation procedure where the infant first learns simple word-object pairs and then is tested on the nature of the learned word-object association. The habituation task used in this experiment has been successful in demonstrating the ability of 14-month-old infants to learn novel words that are phonetically *dis*similar (Werker, Cohen, and Lloyd, 1995).

By testing simple word-object association, this technique allows us to test an early stage of word comprehension, "recognitory comprehension" (Oviatt, 1980), where the infant maintains an association between the linguistic form and the intended referent. Recognitory comprehension does not require the level of comprehension or cognitive skills needed for referential use, and thus a study of recognitory comprehension may not be plagued by the interpretive difficulties of some of the earlier studies. The task requires no understanding of verbal commands, no speech production, and a minimal amount of motor movement for the child, relying simply on differential visual fixation.

This procedure has the child learn the novel word-object pairs within a few exposures, requiring only a short period of participation from the child. Successful performance in the test phase requires that the child discriminate and also compare the stimuli to previously stored information. In the habituation task prerecorded stimuli are used where a video image of the stimulus is paired with the auditory stimulus. Stimuli are presented by a computer in a partially infant-controlled habituation paradigm.

The studies in this thesis were designed to determine whether infants at an early stage of word learning are able to form detailed word-object associations that take advantage of the speech-discrimination sensitivities demonstrated in early infancy.

EXPERIMENT 1

Experiment 1 was designed to address whether infants are representing enough information to notice a switch in word-object association when the words used are phonetically similar. In Experiment 1 infants were habituated to 2 word-object associations, which used nonsense words that are phonetically similar. Previous research in our lab has shown 14-month-old infants are able to learn word-object associations for words that are phonetically *dis*similar (Werker, Cohen, and Lloyd, 1995) using a procedure identical to the one described here. Infants are habituated to two word-object pairs, and then tested for dishabituation in looking time when either the object or the label is switched with that belonging to the other pair. Two test trials are presented; a "switch" trial, that contains a switch in either the label or the object, and a "same" trial, where there is no switch in the pairing. The order of presentation of these trials is counterbalanced.

Predictions

If infants are able to form detailed word-object associations when the words are phonetically similar, they should dishabituate to a change in the word-object association. If infants representations are insufficiently detailed, then infants should not dishabituate to a change in the pairing. A comparison between the "switch" test trial, and the "same" test trial will indicate whether infants are dishabituating to a change in the pairing. A repeated-measures ANOVA will be conducted, with order of test trials ("same" or "switch" first) included as a between-subjects factor. Order of testing allows the examination of the possibility that there is a change in looking to the "same" trial when it follows a "switch" trial.

Method

Participants

The subjects were 32 14-month-old infants without significant health problems (based on parental report). The attrition rate for this study was 30%.

Subjects were selected by appropriate age from the infant data base in Dr. J. F. Werker's lab. These infants were recruited mainly through visiting new mothers at B.C. Women's Hospital, but also through voluntary response to public service announcements. At the time of recruitment parents consented to be contacted about the possibility of participation. Participating infants were given an "infant scientist" t-shirt and diploma.

Stimuli

Audio stimuli.

The audio stimuli were infant-directed tokens, presented with different infant-directed speech (IDS) intonation. The use of IDS is thought to increase interest and perhaps to simplify the discrimination part of the task for the infant (Karzon, 1985). The habituation stimuli were two nonsense CV labels: /bɪ/ and /dɪ/. These stimuli differ in place of articulation of the initial consonant. An additional nonsense label, /pɔk/, was presented during the pre-and post-test trials. /pɔk/ was chosen as it is maximally different from the habituation tokens.

The tokens were recorded in a sound-proof booth by an English-speaking female. To approximate IDS, the speaker was asked to imagine she was speaking to an infant.[2] She produced 7 exemplars of each syllable in an infant-directed, rise-fall intonational phrase. Each of the 7 exemplars is

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[2] There is work by Fernald and Simon showing that IDS is different when an infant is present than when a speaker is imagining an infant to be present. However, the latter is more like IDS than typical ADS (Fernald & Simon, 1984).

approximately 0.7 seconds in duration, with a 1.5 second silent interval between exemplars. This yields audio files that are 14 seconds in duration.

Acoustic analyses on a number of factors revealed /bɪ/ segments (637.12 ms) to be slightly longer than /dɪ/ segments (624.54 ms). Differences included the /dɪ/ formant transition (56.33 ms) being twice as long as /bɪ/ formant transitions (25.46 ms).

Factors in selection of auditory stimuli.

In considering the selection of our auditory stimuli there are a number of factors that need to be considered: familiarity, frequency, selectivity, and perceptual distinctiveness.

Research has shown that familiarity facilitates word learning in children, and specifically has been shown to affect learning of phonetically-similar words (Barton, 1978). This would suggest that in selecting the stimuli, level of familiarization should be fully balanced. In our case, we decided to use all unfamiliar word forms.

Also important to consider in selecting stimuli is the evidence from early speech perception which suggests children are sensitive to the frequency of the sounds presented around them (Jusczyk, Luce, & Charles-Luce, 1994). Nine-month-old infants (but not 6 month old infants) presented with lists of words that contain high-probability phonotactic sequences and lists that contain low-probability phonotactic sequences for their languages listened longer to the high-probability lists. This research suggests the stimuli chosen should have high-probability phonotactic patterns.

The third area of research that needed to be considered in stimuli selection was some work on children's phonological productive selectivity. Children attempt to say only words they are currently able to articulate, at least up until two years of age (Dobrich & Scarborough, 1992). This

phonological selectivity effect has been observed in naturalistic (Ferguson & Farwell, 1979) and experimental data (Schwartz & Leonard, 1982). This selectivity effect has been observed to be strongest for word-initial consonants (Ferguson & Farwell, 1979; Shibamoto & Olmsted, 1977). It should be noted, however, that children's productive selectivity does not appear to be reflecting a comprehensive selectivity (Schwartz, Leonard, Loeb, and Swanson, 1987; Schwartz & Leonard, 1982). The observed selectivity effect may be relevant depending on the relationship of comprehension and representation to production. As we are uncertain whether the observed selectivity is due to perceptual or production factors, it seemed wise to use phonemes that are generally thought to be in children's vocal repertoire. The stimuli selected, /bɪ/ and /dɪ/ were comprised of the phones: /b/, /d/, and /ɪ/. Both /b/ and /d/ are common in babbling and in children's early words (Locke, 1983), and are easily discriminated by children 1;5 to 1;10 (Schvachkin, 1973; Garnica, 1973). Similarly, /ɪ/ is in the vocal repertoire of children of this age.

On the basis of previous perception studies, there are also reasons to select these stimuli. Difference in place of articulation is a relatively easy discrimination for infants to make (Jusczyk, Copan, & Thompson, 1978; Jusczyk & Thompson, 1978; Kuhl, 1987; Trehub, 1976). Several studies specifically testing /b/ versus /d/ have shown young infants can discriminate /ba/ from /da/ (e.g., Werker et al., 1981). We did not want to use /ba/ and /da/, however, because they are often in the productive vocabularies of 14-month-old infants as labels for other objects (e.g. 'ba' for 'bottle' or 'ball', 'da' for 'Dad'). Theories such as Mutual Exclusivity and notion of Contrast (e.g., Markmán, 1991) hold that infants expect each object or class of objects to have only a single label. This may be a problem if the inverse is also true for

infants, where they expect every label to only apply to a single object or class of objects. Many other vowels paired with [b] and [d] also constitute possible words for young infants. The syllables /bɪ/ and /dɪ/ were the best examples of CV forms using /b/ and /d/ that were not likely to be words to the infant. As a final control for discriminability, 5 adults were tested on their ability to discriminate/bɪ/ from /dɪ/, in the same room, under the same testing conditions as those used for infants, and all achieved 100% accuracy.

Visual stimuli.

Two objects ("poky" and "roundy") made from brightly coloured modeling clay were used for the habituation and test trials and another object, a commercially manufactured water-wheel, was used for the pre- and post-test trials (Figure 1). The objects take up a 13.50 degree vertical and 13 degree horizontal visual angle. The visual stimuli were videotaped against a black background and transferred to a Laser Disc format. The stimuli were taped moving back and forth across the screen at a slow and constant speed (roundy = 14.336 cm/s; poky = 15.590 cm/s). The stimuli are the same as those used by Werker, Cohen and Lloyd (1995).

Factors in the selection of visual stimuli.

There is a notable lack of research on the role of attention to perceptual attributes in conceptual judgments in young infants (for a review see Jones and Smith, 1993). The existing research on infant category perception does suggest, however, that when labels are involved, the most important factor is overall object shape (Baldwin & Markman, 1989). The stimuli used in these experiments differ in overall shape. Color is held constant, but there are differences in shape and number of elements in the pattern. To ensure that one figure is not inherently more attractive than the other, the habituation objects were composed of equivalent amounts of red, blue and yellow clay,

and were balanced for size, brightness and colour. Although there is evidence that children come to realize that the rules for category membership can entail more than surface similarities, this realization is generally not seen until later in development than the 14 month period we are interested in (Davidson & Gelman, 1990).

We decided to use moving objects as in earlier related work, infants were unable to learn the word-object pairing if the stimuli were static (Werker, et al., 1995).

Apparatus

The infant was seated on the parent's lap facing a Mitsubishi HC3905, 45 cm video monitor with 640 dot by 480 line vertical resolution. A BOSE 101 speaker was located below the monitor. The monitor was surrounded by a black cloth background which stretched the width and height of the room. The 2 side walls are bare of decoration. A grey striped tapestry was hung on the rear wall. The room was dimly lit by a single fluorescent bulb. The video monitor was located about 70 cm from the infants eyes.

Directly above the monitor was a Panasonic PV-5770K video camera. A 6 cm hole was cut in the black cloth to accommodate the camera lens.

To ensure the parent cannot detect the audio or video stimuli being presented to the infant two precautions are taken. The parent wore Koss Pro/4AA headsets over which female vocal music was played from a Panasonic RX-C5700 portable stereo. The parent also wears a visor (felt cloth hanging from a baseball cap) to prevent detection of the visual stimulus.

A closed circuit system allows the experimenter, located in an adjacent room, to record the child's behaviour on line. The experimenter watches the child on a NECPM 1271-A monitor in the observation room and records the duration of the child's looking to the video stimulus by pressing a designated

key on the computer. To begin each trial a flashing red light was presented. When the infant looked at the flashing light, the experimenter initiated the next trial by pressing a button on the computer. Presentation of the stimuli was controlled by custom software on a MacIIfx computer interfaced with a Sony 1550 Laser Disc Player. The video segment for each video image from the laser disc player is synchronized with a digitized audio file by the computer and the signals are transmitted to the monitor and speaker (see Figure 2).

The computer stored the length of the infants visual fixation, as recorded by the experimenter, for each trial, and prints out a summary record of trial-by-trial fixation time.

Procedure

The parent brings his/her infant into the lab, at a time scheduled by the research coordinator that does not conflict with the infant's nap time. The procedure is explained to the parent, who then signs a consent form. The infant and parent are taken to the testing room and positioned for the experiment. The experimenter returns to the observation room to begin the procedure.

The infant is randomly assigned to participate in a pre-selected order, from a list of possible orders, which has been randomly sequenced. The infants are tested using a modified habituation paradigm, identical in structure to that used by Werker, Cohen, and Lloyd (1995). Each trial begins when the infant fixates a flashing red light and each trial lasts for 14 seconds. On the first trial, infants are presented with a pre-test stimulus, the word-object pair of 'pok' and the water wheel. This assures that infants are interested in the procedure and provides a baseline looking rate. During the habituation phase the infant is shown two word-object pairs (e.g., /bɪ/ and

"roundy", /dɪ/ and "poky"). Every block of four trials contains two instances of each word-object pairing presented alternately in semi-random order (ABAB, ABBA, BAAB, BABA, etc.). Looking time is calculated on-line, and when the average looking time across a 4-trial block decreases to a set criterion (sixty-five percent of the first block of 4 trials), the habituation phase ends. The infants must see a minimum of 12 habituation trials.

When criterion is met the test phase begins. Two trials comprise this phase. One trial is a "same" trial, where one of the pairings presented in the habituation phase is presented again. The other trial is a "switch" trial and contains a novel pairing, composed of one of the objects presented paired with the label it was not paired with during the habituation phase. The order of presentation of these trials is counterbalanced across subjects. The final phase in the experiment is the post-test trial, where the child is again presented with 'pok' and the water wheel. This trial is included to ensure that the child is still paying attention. It is expected that looking time will recover to near baseline level during this final trial. Total testing time is approximately 5 minutes.

Two subjects were assigned to each of the 16 possible orders. These orders ensure counterbalancing of each label paired with different shapes, and also ensure all possible combinations in the test trials (See Table 3).

Results and Discussion

Efficacy of Testing

To determine the reliability of the coding, a second trained coder scored the looking times of 25 % of the usable subjects off-line. A Pearson product-moment pairwise correlation of on- and off-line scores was .95 or greater for all scored subjects.

To determine that infants were not fatigued, and were still paying attention to the stimuli, a correlated t-test was conducted on "last block" and "post-test" looking times.[3] A significant difference would indicate that children are still paying attention, as they show recovery to a very different stimulus. A t-test reveals significant recovery to the post-test trial, t (31)=-19.768, p=.00001.

The last phase of habituation and the "same" test trial were compared to test for spontaneous recovery. The results were non-significant, t (31)=.004959, p = .9961 (two-tailed).

Analysis of the Data

The primary question of interest in this experiment is whether infants notice a switch in the word-object pairing. Duration of fixation to the "switch", and "same" test trials was compared using a one-way repeated measures Analysis of Variance (ANOVA). Order of test trials (switch trial first, same trial first) was included as a between-subjects factor. If children are learning the word-object associations, we would expect a main effect of the repeated measure, with significantly longer looking times to the "switch" trial than to the "same" trial. The between subject variable might help in explaining variations in the magnitude of the differences in looking to the "same" trial and the "switch" test trial. We might predict longer looking to the "same" trial when it follows a "switch" trial, if the infant notices the switch, and dishabituates, showing renewed interest in the stimuli.

The ANOVA was conducted on the data from the 32 subjects (16 girls, 16 boys) who completed Experiment 1. There was no main effect of trial type,

[3] In our original design of the experiment we planned to conduct this analysis using pre-test and post-test trials. Pilot data revealed that the pre-test often appeared to serve the purpose of attracting the infant's attention to the screen and did not result in a useful measure of looking time. We subsequently decided the most important evidence for recovery was to the post-test trial as compared to the last block of looking.

$F(1,29) = .609$, $p = .4413$ (switch trial M= 6.504 secs., SE= .674 ; same trial M= 5.898 secs., SE = .616) (see Figure 3). There was no main effect of order, $F(1,30)$= 1.143, n.s. or significant interaction, F (1,30)= .856, n.s.. This suggests infants are not responding to a switch in the word-object pairing.

Discussion

The finding of no significant difference in looking times to "switch" and to "same" indicates 14-month-old infants have difficulty making word-object associations when the words to be learned are highly phonetically similar. It is not immediately clear, however, why infants might have had this difficulty. Successful performance in Experiment 1 requires a number of competencies on the part of the child. The child must first form a detailed representation of the two word-object associations, must notice a switch in the pairing during the "switch" test trial, and must behaviourally register their notice of a switch by increased looking within the 14 seconds of the "switch" trial. It may be the task is very complicated for the child, and that in a simpler task the child may be able to demonstrate learning of the phonetically similar word-object associations.

In order to examine this possibility, a second experiment was conducted where the child was presented with a simpler task. To simplify the task, we decided to habituate the infants to a single word-object pairing, and then to test them with a switch in either the object or the label. If the observed difficulty infants have in Experiment 1 is related to memory demands, we would expect infants to show less difficulty in both a word switch and an object switch control study. If the difficulty is with the formation of the association, infants may have difficulty in both control studies. If the difficulty is with the objects or words, than we would expect to see a significant difference in looking to the "same" and the "switch" test

trials in the condition that is not difficult for the infant, but no significant difference in the condition that is difficult for the infant.

EXPERIMENT 2

Experiment 2 was designed to determine if infants respond to a switch in pairing after being habituated to a single word-object pair. We were concerned that the previous task was too difficult for the infants, and attempted to decrease some of the demands of the task, such as memory. Alternatively, infants may have difficulty noticing a switch in Experiment 1 because of difficulty in discriminating either the words or the objects. To test this, we ran a control study, where infants were habituated to one word-object pairing, and then were either tested with a novel object, but with no switch in the word (Experiment 2A), or with a novel word, but with no switch in object (Experiment 2B).

Experiment 2 A

Experiment 2A was designed to determine if infants respond to a switch in object after being habituated to a single word-object pair.

Predictions

As in Experiment 1, if infants notice a switch we expect to see increased looking to the "switch" trial, as compared to the "same" trial.

Method

Participants

A new sample of 16 14-month-olds was tested. An additional 9 infants were tested but were not included in the analyses because of experimenter error (n=1), they were not visible (n=4), the experiment had to be stopped because they were fussing (n=3), or they did not habituate (n=1).

Stimuli

Remained the same as for Experiment 1.

Apparatus

Same as Experiment 1.

Procedure

The habituation process differed from that of Experiment 1 in three major aspects. Firstly, the habituation phase included only **one** word-object pairing, as opposed to the two pairings presented in Experiment 1 (see Table 4 for orders used in 2A). Secondly, the habituation criterion was changed from Experiment 1. The habituation criterion was measured over a block of two trials as opposed to a block of 4 trials. Pilot work suggested that requiring habituation over 4 trials made the procedure too long. Every habituation trial in this experiment is the same, which means a block of two trials in this experiment can be seen as equivalent to a block of 4 trials (2 of each kind) in Experiment 1. The habituation criterion was that looking time on each of the last two habituation trials must be less than or equal to sixty-five percent of the average of the two highest trials. Finally, in Experiment 1, all infants were familiarized for a minimum of 12 trials whereas in this experiment the minimum number of habituation trials was reduced to 8 trials.

Results and Discussion

Efficacy of Testing

To determine the reliability of the coding, a second trained coder scored the looking times of 25 % of the usable subjects off-line. A Pearson product-

moment pairwise correlation of on- and off-line scores was .95 or greater for all scored subjects.

To determine that infants were not fatigued, and were still paying attention to the stimuli, a correlated t-test was conducted on "last block" and "post-test" looking times. A significant difference would indicate that children are still paying attention, as they show recovery to a very different stimulus. A t-test reveals significant recovery to the post-test trial, t (15)= 24.567, p<.0001.

A t-test was conducted on looking times during the last phase of habituation and the "same" test trial to test for spontaneous recovery. The results were significant, t (15)=-2.221, p = 0.0228 (two-tailed). This is not a concern as a t-test conducted only on those infants who received the "same" test trial before the "switch" trial, did not show a significant difference, t (7)= -1.344, p = .1104. This suggests the effect may be carried by those infants who receive the "same" trial following the "switch" trial, whose looking to "same" may be affected by their previous exposure to the "switch" trial, rather then by any spontaneous recovery.

Analysis of the Data

The primary question of interest in this study is whether infants notice a switch in the word-object pairing, when the switch is a switch in object. This is most directly assessed by comparing duration of looking to the "switch" and "same" trials, using a repeated measures ANOVA. The between subjects factor of order of presentation of the test trials was also included.

As in Experiment 1, if children are noticing a change in the pairing, we would expect a main effect of trial type, with longer looking to a "switch" trial. The between-subjects factor was included, as the magnitude of the

difference between looking to "switch" and "same" might be affected by the order of presentation of the test trials.

A repeated measures ANOVA was conducted on the data from the 16 subjects (8 girls, 8 boys) who completed Experiment 2A. There was a significant effect of trial type, F (1,14) = 21.515, p = 0.0004, with infants looking longer to switch (M=10.710, SE = .746) than to "same" (M=6.495, SE=.877) (Figure 4). There was not a significant effect of order, F (1,14)=.108, n.s. or a significant interaction, F (1,14)= .062, n.s.

Discussion

The results of experiment 2A indicate that infants have no trouble visually discriminating the objects. The infants may be noticing a new object with a familiar word, or may simply be noticing a new object and not even be listening to the word. These results also suggest that a factor like the greater memory demands of Experiment 1 may have made the task more difficult for the child. If the decreased memory demands of Experiment 2 is what is now allowing the child to form the detailed association, we would predict infants would similarly be able to discriminate a change in the words, after habituation to a single word-object pair.

Experiment 2 B

Experiment 2B was designed to determine if infants respond to a switch in word after being habituated to a single word-object pair.

Predictions

We would predict that if infants are noticing a switch in the label they will show increased looking time in the "switch" test trial as compared to the "same" test trial.

Method

Participants

A new sample of 16 14-month-olds was tested. An additional 9 infants were tested but were not included in the analyses because they were not visible (n=4), the experiment had to be stopped because they were fussing (n=4), or they did not habituate (n=1).

Stimuli

Remained the same as for Experiment 1.

Apparatus

Same as Experiment 1.

Procedure

Same as Experiment 2A, except that rather then receiving a "switch" trial that contained a switch in object, infants received a switch in label (see Table 5 for orders used in Experiment 2B).

Results and Discussion

Efficacy of Testing

To determine the reliability of the coding, a second coder scored the looking times of 25% of the usable subjects. A Pearson product-moment pairwise correlation of scores from coder 1 and coder 2 was .95 or greater.

To ensure infants were not fatigued, and were still paying attention to the stimuli, a correlated t-test was conducted on "last block" and "post-test" looking times. A significant difference would indicate that children are still paying attention, as they show recovery to a very different stimulus. A t-test reveals significant recovery to the post-test trial, t (15)=34.271, p<.0001.

A t-test was conducted on looking times during the last phase of habituation and the "same" test trial to test for spontaneous recovery. The results were significant, t (15)=-3.084, p = .0.0076 (two-tailed). This is not a

concern as a t-test conducted only on those infants who received the "same" test trial before the "switch" trial, did not show a significant difference, t (7)= -2.093, n.s.. This suggests the effect may be carried by those infants who receive the "same" trial following the "switch" trial.

Analysis of the Data

The primary of question of interest in this study is whether infants notice a switch in the word-object pairing, when the switch is a switch in word. Duration of looking to the "switch" and "same" trials was compared, using a repeated-measures ANOVA. The between-subjects factor of order of presentation of the test trials was also included.

As in Studies 1 and 2A, if children are noticing a change in the pairing, we would expect a main effect of trial type, with longer looking to a "Switch" trial. The between-subjects factor was included, as the magnitude of the difference between looking to "switch" and "same" might be affected by the order of presentation of the test trials.

A one-way repeated measures ANOVA was conducted on the data from the 16 subjects (8 girls, 8 boys) who completed Experiment 2A. There was a no significant main effect of trial type, F (1,14) = .056, p = .8171 (switch trial: M=6.888, SE = .745, same trial: M= 7.120, SE = .741)(Figure 5). There was not a significant effect of order, F (1,14)=.052, n.s., or a significant interaction, F (1,14)=.265, n.s..

Discussion

The results of Experiment 2B suggest infants are not distinguishing the two phonetically-similar words even in this more simplified version of the word-object association task. This result is quite surprising given the known discrimination abilities of infants this age. Although the possibility exists that, for some reason, infants are unable to perceptually discriminate /bɪ/

from /dɪ/, the more likely explanation is that even this more simplified task does represent a word-learning task to the infant. As was shown in Experiment 1, infants treat words that are this phonetically similar as equivalent in a word-learning task.

COMPARISON OF STUDIES 1 AND 2

The results of Experiment 2B suggest infants are not discriminating the two phonetically-similar words. This failure to discriminate the words may explain the results of Experiment 1. It may be infants are encoding enough information about the object to notice a switch in the object, but are not encoding enough information about the word to notice a switch in the word. To determine if the difficulty in Experiment 1 is a results of the infants' failure to notice a switch in the word, an additional ANOVA was conducted to probe the individual test trials in more detail. For one half of the infants the change between the two test trials (regardless of the order of test trial presentation) was a change in word, for the other half of the infants the change was a change in the object. We conducted an analysis on the change infants experienced between the two test trials. The between subjects factor was the type of change. If, for example, Test Trial 1 was "roundy" and /bɪ/, and Test Trial 2 was "roundy" and /dɪ/, it would be coded as a change in word. The within-subjects variable was again trial type. We included the type of change as a between-subjects factor.

There was a main effect of type of change, F (1,30) = 8.025, p = .0082, with greater looking when there was a change in object (M=7.523, SE = .674), than when there was a change in word (M=4.879, SE = .523). There was no significant interaction, F (1,30)=.841, n.s., or main effect of trial type, F (1,30)=.609, n.s. (Figure 6). This analysis focusing only on the two test trials in

Experiment 1, provides further verification that infants are encoding more detailed information about the object than the word, and that the word may be causing the difficulty in Experiment 1.

GENERAL DISCUSSION

The research reported in this thesis provides an indication that for children younger than those previously tested, in a task simpler than previously reported, learning phonetically similar words is difficult. Previous studies have come to the same conclusion, but they have tested older children and have used tasks that assess full referential comprehension, where the child can use the word alone to stand for the object. We were interested in assessing the perceptual sensitivities infants bring to word-learning at the earliest stages of word learning and thus decided to concentrate on "recognitory comprehension" (Oviatt, 1980). We tested infants using a habituation procedure which requires minimal cognitive abilities on the part of the child, eliminating demands such as understanding of verbal instructions in the task.

The present series of experiments shows 14-month-old infants have difficulty learning word-object associations when the words are phonetically similar, although previous research indicates they are able to do so when the words are phonetically dissimilar (Werker et al., 1995). In Experiment 1, infants were habituated to 2 word-object pairings, and when tested did not appear to notice a switch in the word-object pairing. It was unclear whether this difficulty was related to discrimination of the labels, discrimination of the objects, or to cognitive difficulties in forming the association. Experiment 2 was designed to reduce the memory demands for the infants by habituating them to only a single word-object pair. Experiment 2A showed that after habituation to a single word-object pair, infants dishabituated to a switch in

the object, indicating infants are able to discriminate between the objects, and perhaps expect them to have different labels. Experiment 2B was designed to test whether infants notice a change in label. Infants did not dishabituate to a switch in the label, suggesting the infants did not encode enough information about the label to notice the switch. These results suggest that infants do not use detailed representations of phonetically-similar words.

The finding that 14-month-old infants have difficulty in recognitory comprehension of phonetically similar word-object pairs provides strong evidence that infants are not using the full range of their phonetic-discrimination abilities in word learning, but it does not inform us as to "why".

Two primary hypotheses address the apparent decline of perceptual-discrimination abilities in infants as they move from speech perception into word learning. The first is that there is a change in their phonetic-perception abilities, where they can no longer make the fine discriminations they demonstrate at younger ages. This can be tested using a straight perceptual-discrimination task. The second, and more likely, hypothesis is that there is no change in the phonetic-perception abilities, but that the infants are not using the abilities in a task that requires mapping minimal phonetic distinctions on to semantic distinctions.

There are several findings which support the second hypothesis. The speech-perception abilities seen in the younger infant may not be the functional abilities that the infant uses in word learning. Charles-Luce and Luce (1990) suggest that in the early stages of language acquisition young children are using only very broad phonetic representations. The evidence cited to support this is that young children's lexicons are comprised primarily

of words that are highly phonetically dissimilar.[4] If the average comprehension lexicon of a 14-month-old consists of only 125 words (e.g., Benedict, 1979), the phonetic representation need not be very detailed to distinguish one entry from another. Additional support for this hypothesis comes from the research of Walley and colleagues who find increased attention to individual phonemic segments with development (Walley, et al., 1986). It has been suggested (Walley, 1987) that as the infant learns more words there is increased pressure to "fill in" more phonetic detail. As well, Barton (1978) has reported children have more detailed representations for words they know well, than for slightly familiar words. This suggests there may be a link between the pressure to fill in the semantic details of a word and the pressure to fill in phonetic information.

The fact that infants seem to store or represent only partial word forms in the early stages of building a lexicon is suggestive of another explanation for the findings of the present series of studies. Perhaps infants in these studies have represented only the vocalic nucleus of the word (/ɪ/), thus encoding no contrastive information (/b/ vs. /d/). In case study work, Ferguson and Farwell (1979) reported that infants appear to encode initially

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[4] Dollaghan (1994) does not agree with the analysis used and the conclusions reached by Charles-Luce and Luce. She argues they examine only monosyllablic words and therefore their results underrepresent of the actual number of phonologically similar words in the lexicon. She also suggests they make a mistake in selecting the comparison lexicon for adults. Charles-Luce and Luce used a receptive vocabulary for adults, but a productive vocabulary for children. As discussed earlier, the size of the receptive vocabulary generally exceeds that of the expressive vocabulary. Additionally, using the productive vocabulary estimate for children may not accurately reflect the child's underlying representations; the child may have access/ be able to use more detailed information in a comprehension task than the child is able to express. Dollaghan argues that while children do not need to make these fine discriminations they may be capable of doing so. In support of her position Dollaghan analyzed an expressive vocabulary data set for children aged 1;0 to 3;0. and found over 80% of the words had at least one near neighbour, and that nearly 20% had 6 or more near neighbours. The set she analyzed is not a comprehension vocabulary (as she recommends), but rather an expressive vocabulary, in broad transcription. Nevertheless, her method comes closer than that of Charles-Luce and Luce (1990) to measuring the underlying representation.

only the vocalic nucleus. They found this studying 7 infants longitudinally, from about 1 year old until the infants were 19 to 22 months old. Ferguson and Farwell report that in their early productions children readily substitute many different consonants for others that share at least one phonetic feature (e.g., they would substitute /p/ for /t/, which share the features of manner and place of articulation), and insert the initial consonant in various positions, in some cases eliminating it altogether. The only relatively constant factor in the productions was the vocalic nucleus. While this is suggestive of a robust representation of the vocalic nucleus, relative to the consonantal information, this research on productions is difficult to interpret with respect to representations used in comprehension.

If fine-grained representations are not normally required at this stage of word learning, children may fail to encode fine phonetic detail readily. While older infants may still be able to make fine phonetic discriminations, this ability may now be masked by higher cognitive or linguistic functions that may interfere with, or inhibit, the infant's use of finer discrimination skills. If this were the case, older infants would not necessarily discriminate fine phonetic detail in a word-learning task.

If children normally have difficulty encoding and representing fine phonetic detail in the initial stages of word learning, it becomes of interest to ascertain whether some word-learning conditions facilitate access to the information more than others. One possibility is that a more obvious word-learning task than the one used in the present series of studies may help the child make a functional distinction between the phonetically similar words. Although Werker, Cohen, and Lloyd (1995) found that infants were able to learn the word-object association for phonetically *dis*similar words using the same procedure, if the words are too similar extra reinforcement may be

required to enable word learning. Many of the cues present in a natural word-learning task are missing in the word-object association task (such cues include ostensive labeling by the speaker of the object, the use of joint attention, correspondence between labeling and the presentation of the object). If more of these cues were present the infant might be better able to pick up the fine phonetic detail. It is difficult, however, to reinstate many of these cues without losing experimental control, and increasing task demands for the child.

Of all the missing cues, I would argue that the potential lack of correspondence, for the infant, of the auditory and visual stimuli is of particular concern in the present series of experiments. In the present design, we are not sure what infants have habituated to. We can measure habituation to the visual stimulus by assessing infant looking to the image on the screen. There is, however, no analogous measure of habituation to the auditory stimulus as we cannot measure infants' attention to the auditory stimulus directly. The assumption is that infants are listening only when they are looking, but this assumption may be flawed. Thus it is impossible to determine when infants lose interest, whether any or all of that loss of interest can be attributed to their becoming habituated to the auditory stimulus. Notice, this problem exists only if infants are encoding the word and the object independently. If, instead, infants are listening to the word as a label for the object, then it is safe to assume that looking time is an appropriate measure of habituation.

This problem may also be compounded by the "attention facilitation effect". As children begin to establish word-object associations, the presence of a label increases children's attention to the object (Baldwin & Markman, 1989). Baldwin and Markman reported that when 10 to 14 month olds are

presented with unfamiliar toys, the presence of a label combined with pointing increases the amount of attention directed to an object compared with either pointing alone or no signal. Baldwin and Markman posit this may be related to intersensory facilitation where the presence of a sound will increase the infants' arousal and stimulate them to attend more. Similar findings have recently been reported by Waxman and Markow (in press) where the presence of a label increases infant ability to detect the criterial visual features defining a category. These findings would suggest that the presence of the label in Studies 1 and 2A may help the child to learn about the objects. There is, however, no evidence for the reverse, i.e., that the presence of an object facilitates the amount of attention directed to the label. Indeed, it is equally possible that the presence of an object detracts infants from listening to a word.

Extrapolating from these findings, I would suggest that in order to increase the likelihood of infants forming a strong representation we should present the label only in the presence of the object and vice-versa. To help increase the correspondence, we could repeat the experiment using an infant-controlled procedure. In such a procedure the audio and visual stimuli would be yoked together, so infants could not receive one without the other, thus, helping them form a stronger association. While this procedure moves in the direction of a more obvious word-learning task, there is no loss of experimental control, as is a problem in many other word-learning tasks.

Three Caveats

There are three stimulus factors that could have interfered with successful performance of this task.

Infants may have difficulty making the discrimination because of the similarity of the objects. Although the results of Experiment 2A indicate

infants are able to discriminate between the visual stimuli used, it is possible that these objects are still very similar to children. The perceived object similarity may make it more difficult for children to pull apart the similar-sounding words. For example, children may be focusing their attention on the task of encoding differences between the objects, and thus neglecting to encode detailed information about the auditory stimuli. Perceived object similarity could also interfere with successful discrimination of the auditory labels if the child assigns the two objects to the same basic category, on the basis of their visual similarity. In this case, the child may be expecting only a single label and will thus listen for similarities rather than differences in the words. If we repeated the experiment using objects that are very distinct visually, we would eliminate this possible factor. However, the obvious ease with which infants discriminate the objects in Experiment 2A and in other experiments (Werker et al., 1995) suggests this is unlikely to be the problem for infants.[5]

A second concern regards the audio stimuli used in these experiments. The stimuli, /bɪ/ and /dɪ/, are not proper English word forms. For a word to have proper form in English, it must consist of either a consonant and a long vowel, or else an initial consonant, vowel, and final consonant. The stimuli we used, /bɪ/ and /dɪ/, consist of a consonant and a short vowel. If infants have a concept of a proper word form at a very early age, as suggested by production studies (Demuth, in press; Fee, 1995), they may fail to map inappropriate forms to objects.

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[5] Related to the question of categorization is the nature of the habituation procedure. There is always a concern with habituation tasks that the infants could be responding in the task either whenever they notice a change, or only when there is a really big change, i.e., if the infants categorize the stimuli as not being close enough to be variations of the same word. They might detect the change between /bI/ and /dI/, but find it is not large enough to respond to.

The literature indicating that infants are perceiving or encoding only partial representations, which include only the initial CV segment, suggests, however, that the lack of proper word form is not be a problem for children of this age. Kay-Raining Bird and Chapman (1995) have demonstrated that infants 14 to 15 months of age readily tolerate phonetic substitutions to the final syllable consonant (CVC*)of a novel, but learned, word. This finding indicates children are not encoding detailed representations of phonetic information following the initial CV segment. Similarly, work by Gleitman and her colleagues (Gleitman et al., 1982; Gleitman et al., 1988) and Echols and Newport (1992) suggests that infants may store only stressed and word-initial syllables as their early representations for words. These syllables are often in the form of the stimuli we used. Pollock (1987) used a Preferential-Looking task and found that infants would look preferentially to an object when labeled with a reduced form that contained at least one of the consonants paired with a picture, over an unusual object with no common name. The reduced form that infants recognized across all stimuli tested was the initial consonant followed by the vowel, which is the word form used in our experiments.

The above literature suggests two possibilities; on the one hand that children may expect proper word form, but on the other hand that they may tolerate and/or represent only a portion of the complete word. The first possibility is based on production data, and might not represent what is happening at the level of comprehension. If the second possibility is in fact true, our word forms should not have caused a problem for the infant. Infants should be detecting a switch in word, as we are inserting the contrastive phone in initial position, a position for which infants appear to be able to encode significant detail. In summary, the concern about proper word

form does not appear to be of major significance, but could easily be corrected in future experiments.

Another possible problem with the stimuli is that the labels were embedded in infant-directed speech (IDS). IDS is effective in gaining and maintaining infant attention (Fernald, 1985; Werker & McLeod, 1989) and in facilitating detection and discrimination of phonetic differences (Karzon, 1985). However, in this series of experiments the stimuli were repeated in an IDS intonational phrase. The similar prosodic characteristics of the infant-directed speech may be so salient that the infants were unable to break through the intonational contour to access the contrasting phonetic information in the words, and thus the infants may have failed to notice the phonetic differences. This possibility is discounted by research that suggests even young infants can ignore irrelevant changes in pitch contour to discriminate changes in vowel quality for single syllables, although they cannot ignore the vowel quality to discriminate pitch contour (Kuhl & Miller, 1982). Nevertheless, to eliminate this possibility, we could repeat the experiment with stimuli that do not have a salient prosodic shape.

Final Summary and Conclusions

It appears 14-month-old infants are unable to differentiate phonetically similar words in a word-object association task. Although further research is needed to test the unlikely possibility that there is a change in underlying speech-perception abilities as infants reach the age of 14 months, the more likely explanation is that infant speech-perception sensitivities do not predict performance on word-learning tasks. It seems infants are unable to learn the associations because they are not encoding or not representing enough detail to distinguish the nonsense words /bɪ/ and /dɪ/. In order to encode such

detail, one of two conditions needs to be met: either the child's lexicon must be sufficiently large in this phonetic space to create pressure for the child to fill in more detail, or alternatively, we must set up testing conditions that provide the optimal conditions for encouraging the infant to focus on phonetic detail in the words.

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Table 1. Schvachkin's Sequence of Consonant Discrimination

1. Discrimination between sonorants and articulated obstruents (e.g. m-b)

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3. Discrimination between sonorants (e.g. m-n, l-r).

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5 Discrimination between labials and linguals (e.g. b-d).

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From Schvachkin, p. 109

Table 2. Garnica's Sequence of Consonant Discrimination

1. sonorant vs. fricative; sonorant vs. affricate; nasal vs. glide; glide vs. glide
2. nasal vs. nasal; liquid vs. liquid
3. CVC vs. VC; sonorant vs. stop
4. velar vs. dental or palatal
5. labial vs. nonlabial
6. liquid vs. glide; nasal vs. liquid
7. stop vs. fricative; affricate vs. fricative; alveolar vs. palatal; interdental vs. alveolar
8. stop vs. affricate
9. interdental vs. palatal
10. voiced vs. voiceless

Table 3. Possible orders for Experiment 1. 'S' is for auditory stimulus, and 'V' is for visual stimulus.

	Hab1	Hab2	DisHab1	DisHab2
1	V2,S1	V1,S2	V2,S1	V1,S1
2	V2,S1	V1,S2	V2,S2	V1,S2
3	V2,S1	V1,S2	V1,S1	V2,S1
4	V2,S1	V1,S2	V1,S2	V2,S2
5	V1,S1	V2,S2	V2,S1	V1,S1
6	V1,S1	V2,S2	V2,S2	V1,S2
7	V1,S1	V2,S2	V1,S1	V2,S1
8	V1,S1	V2,S2	V1,S2	V2,S2

	Hab1	Hab2	DisHab1	DisHab2
1	V2,S1	V1,S2	V2,S1	V2,S2
2	V2,S1	V1,S2	V1,S2	V1,S1
3	V2,S2	V1,S1	V2,S2	V2,S1
4	V2,S2	V1,S1	V1,S1	V1,S2
5	V1,S1	V2,S2	V1,S2	V1,S1
6	V1,S1	V2,S2	V2,S1	V2,S2
7	V2,S1	V1,S2	V1,S1	V1,S2
8	V2,S1	V1,S2	V2,S2	V2,S1

		Volume 0-7
V1	Poky	
V2	Roundy	
S1	Di (musical) 09jul93	3
S2	Bi (musical) 09jul93	6

Table 4. Possible orders for Experiment 2 A. 'S' is for auditory stimulus, and 'V' is for visual stimulus.

	Hab1	Hab2	DisHab1	DisHab2
1	V2,S1	V2,S1	V2,S1	V1,S1
2	V2,S1	V2,S1	V1,S1	V2,S1
3	V2,S2	V2,S2	V2,S2	V1,S2
4	V2,S2	V2,S2	V1,S2	V2,S2
5	V1,S2	V1,S2	V1,S2	V2,S2
6	V1,S2	V1,S2	V2,S2	V1,S2
7	V1,S1	V1,S1	V1,S1	V2,S1
8	V1,S1	V1,S1	V2,S1	V1,S1

V1	Poky	
V2	Roundy	
		Volume 0-7
S1	Di (musical) 09jul93	3
S2	Bi (musical) 09jul93	6

Table 5. Possible orders for Experiment 2 B. 'S' is for auditory stimulus, and 'V' is for visual stimulus.

	Hab1	Hab2	DisHab1	DisHab2
1	V1,S1	V1,S1	V1,S1	V1,S2
2	V1,S1	V1,S1	V1,S2	V1,S1
3	V1,S2	V1,S2	V1,S1	V1,S2
4	V1,S2	V1,S2	V1,S2	V1,S1
5	V2,S1	V2,S1	V2,S1	V2,S2
6	V2,S1	V2,S1	V2,S2	V2,S1
7	V2,S2	V2,S2	V2,S1	V2,S2
8	V2,S2	V2,S2	V2,S2	V2,S1

V1	Roundy	
V2	Poky	
		Volume 0-7
S1	Bi (musical) 09jul93	6
S2	Di (musical) 09jul93	3

List of Figures

Figure 1

Figure 2

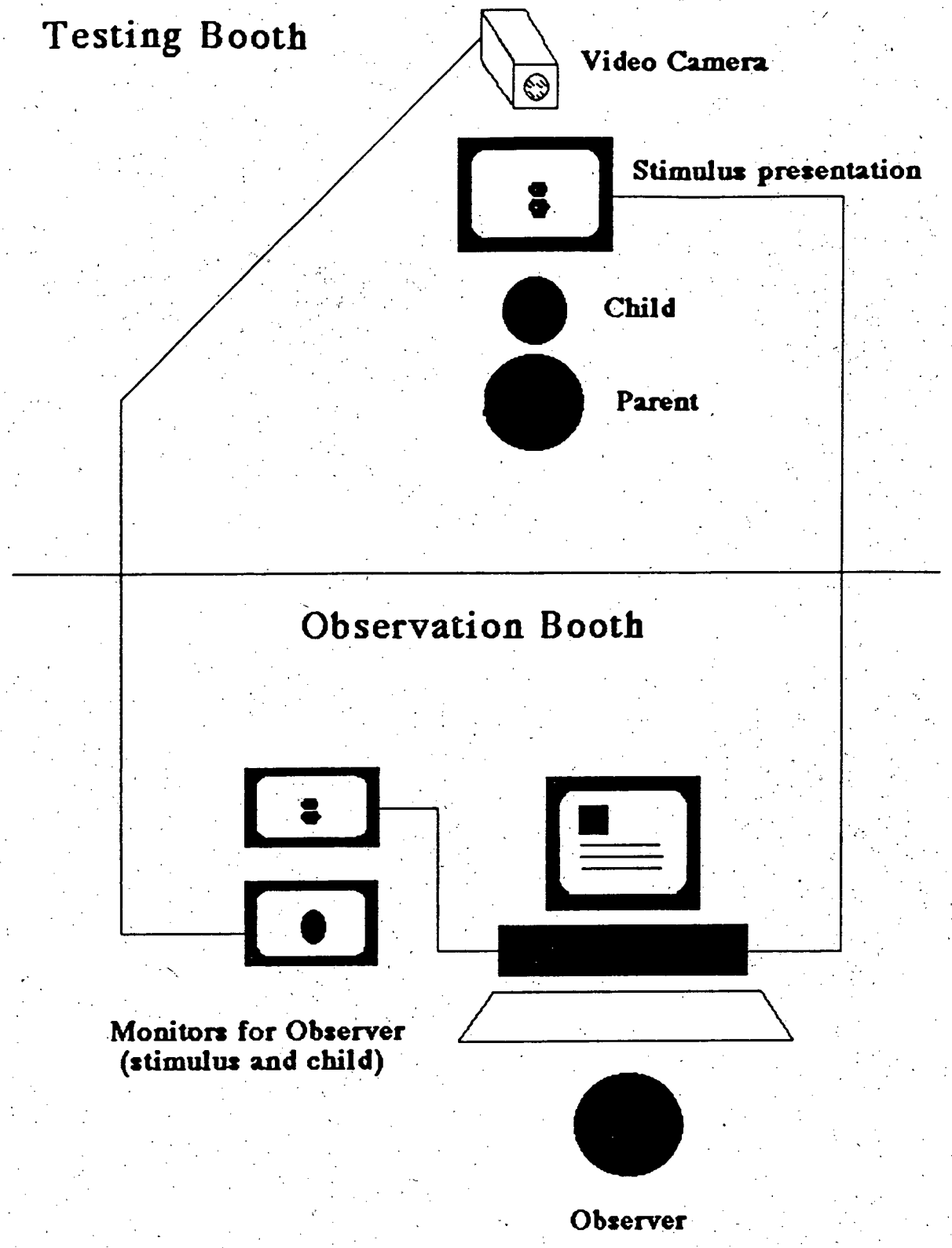

Testing Booth
Video Camera
Stimulus presentation
Child
Parent
Observation Booth
Monitors for Observer
(stimulus and child)
Observer

Figure 3

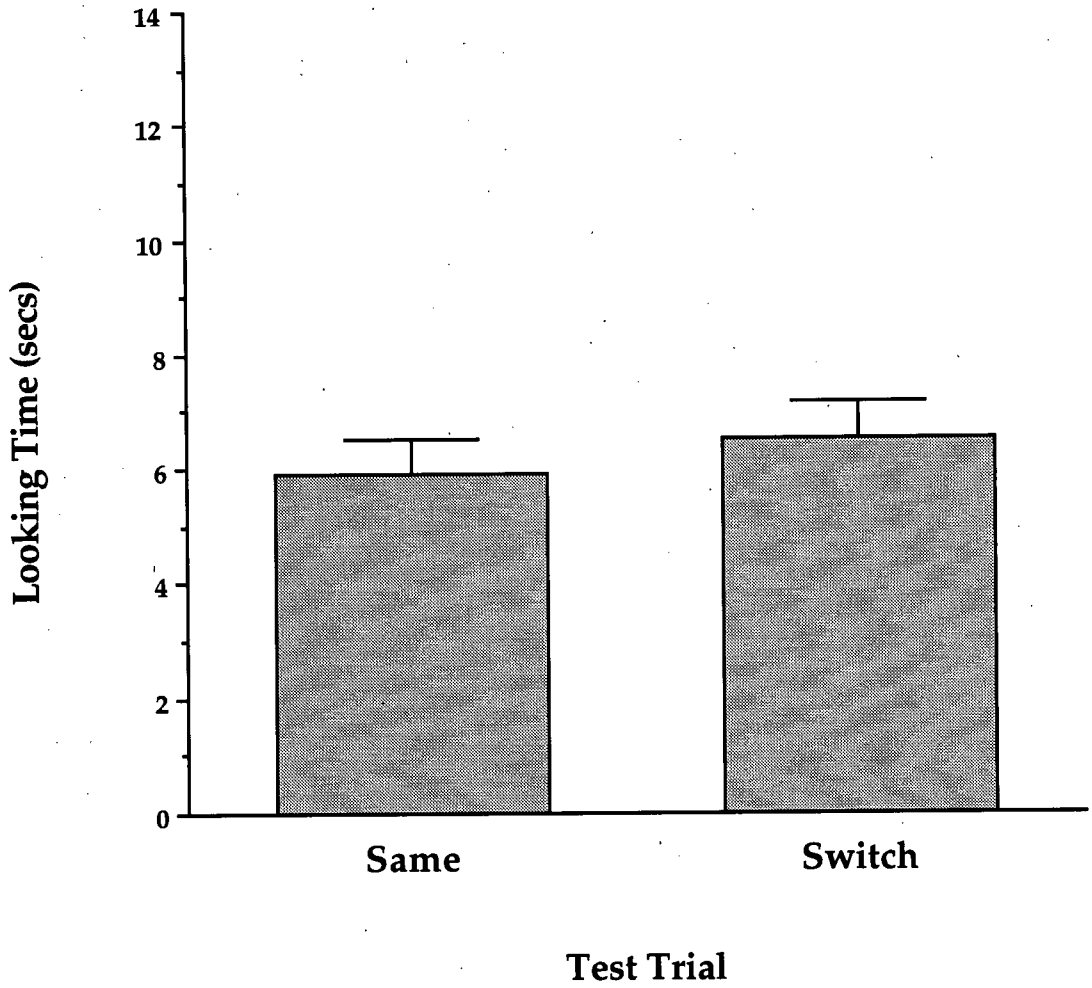


Figure 4

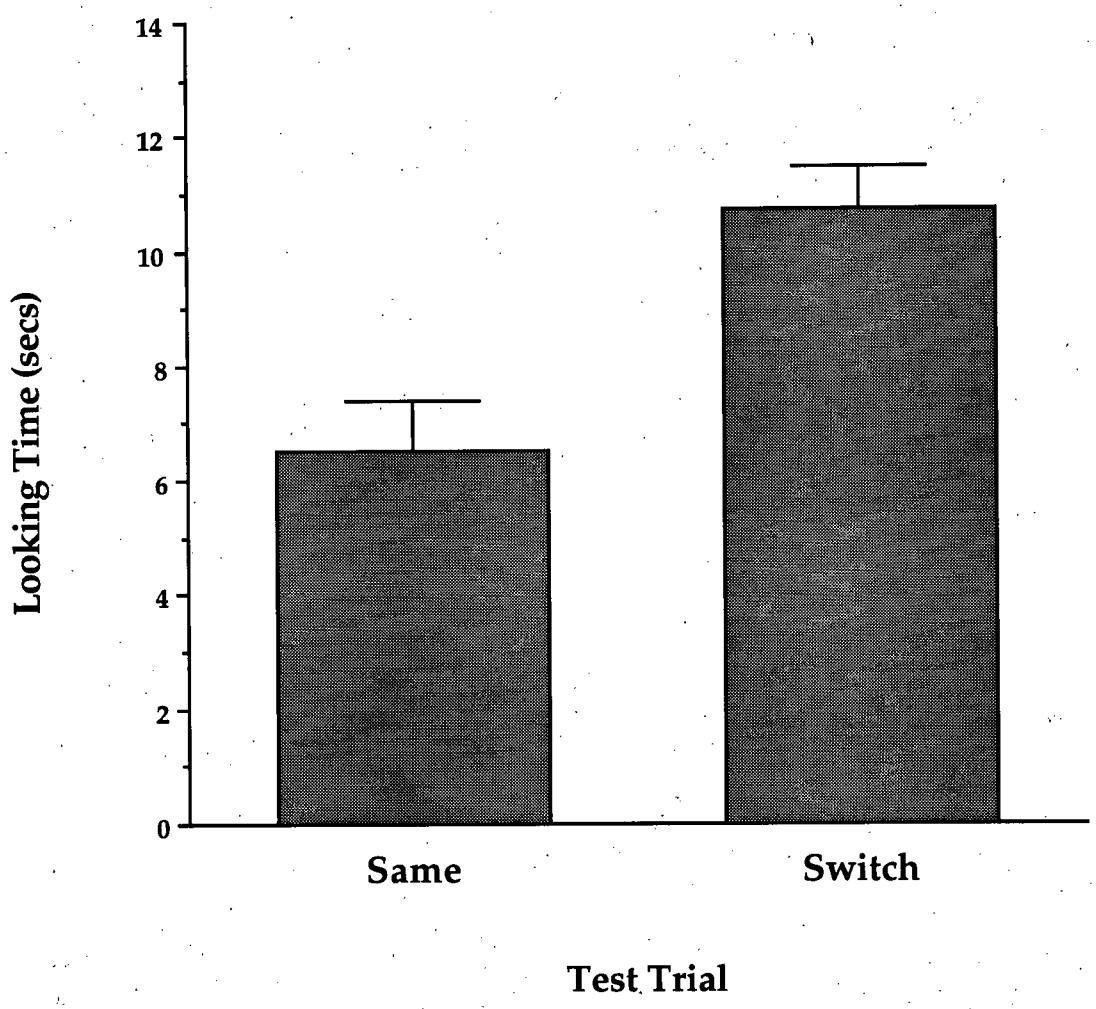


Figure 5

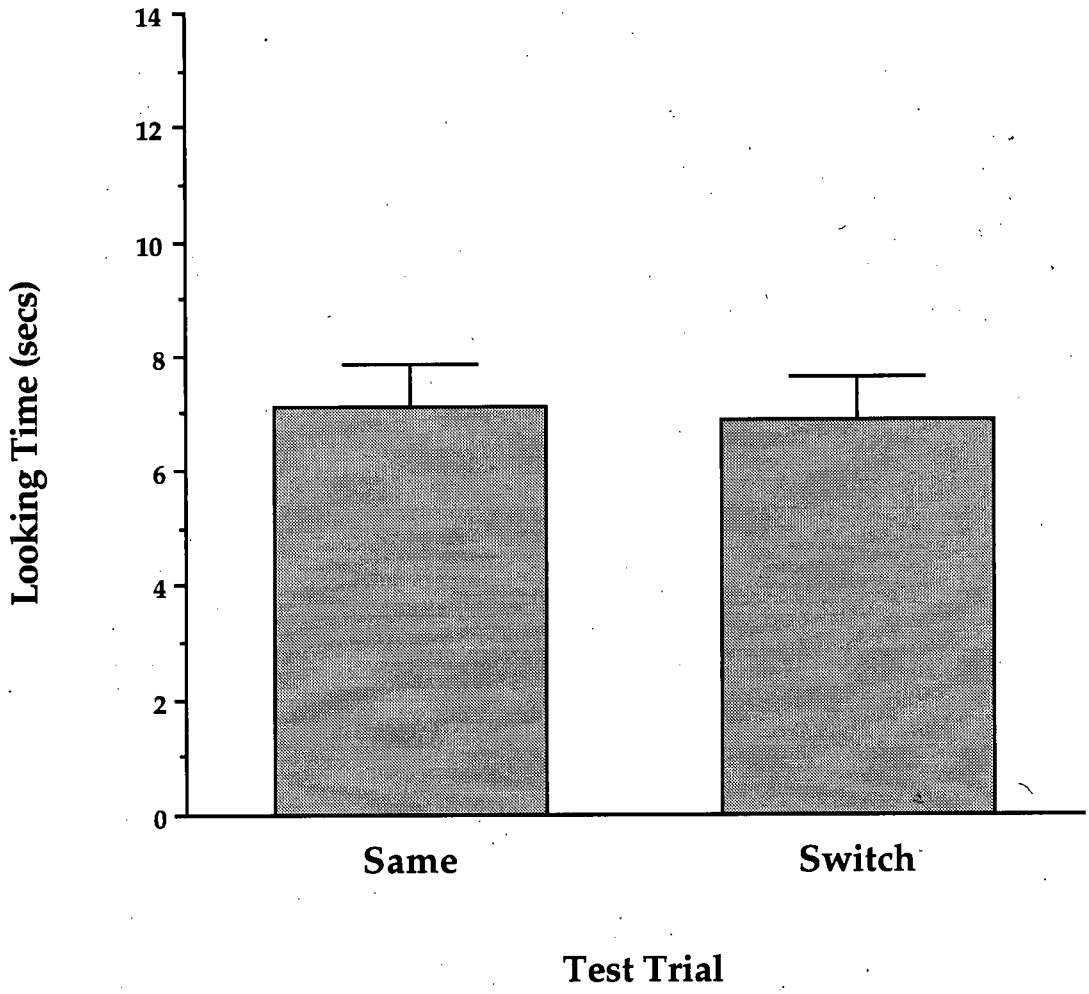
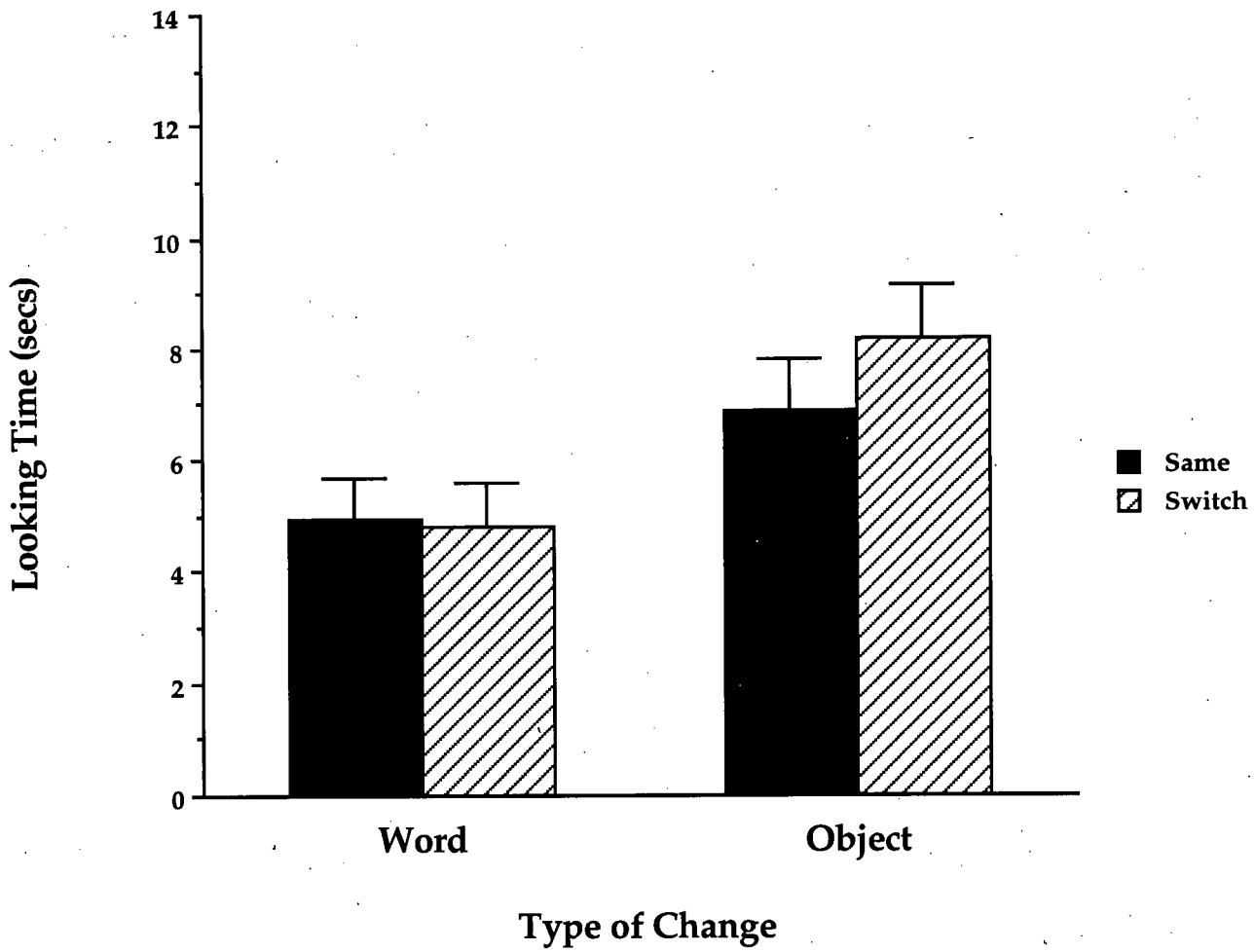


Figure 6


14
12
10
8
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Looking Time (secs)
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Switch
Word
Object
Type of Change