

USING MUSIC TO FACILITATE  
INFANT WORD LEARNING

by

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A THESIS

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## ABSTRACT

Previous studies on infant word-object learning suggest that infants as young as 6-months of age are capable of learning word-object relationships when labeled by their mother (Matayaho & Gogate, 2008). Yet, the unexplored topic that music could influence infants' learning led to the conduction of this present study. Sixteen 6-8 month old infants heard two novel word-object pairs being labeled. Eight of the infants heard the word-object pair being labeled through speech, while the other 8 heard the pair being labeled through song. Results indicated that infants within the song condition performed better than the infants in the speech condition for identifying the correct word-object pair. Un-hypothesized results also indicated that girls performed better than boys. These findings are discussed and if replicated imply that singing, as opposed to speaking words, may facilitate young infants word-object learning.

## DEDICATION

This thesis is dedicated to everyone who helped and guided me through the ups and downs of creating and completing my thesis. In particular, my family, close friends, and academic advisor (Dr. Hernandez-Reif); for keeping me focused and encouraged throughout the time taken to complete the graduate program.

## LIST OF ABBREVIATIONS AND SYMBOLS

$F$	Fisher's $F$ ratio: A ration of two variances
$M$	Mean: the sum of a set of measurements divided by the number of measurements in the set
$p$	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
$t$	Computed value of $t$ test
$<$	Less than
$=$	Equal to
$SD$	Standard deviation

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## INTRODUCTION

### *Infants' experience with music and language*

Introducing music to infants is fascinating and entertaining because infants naturally respond to music. Music has the potential to change infant emotions, whether it be in soothing or exciting ways. Lullabies may quiet a baby while more festive music may generate an active response. So where does it all begin? Amazingly, newborns are able to localize a sound ten minutes after birth, acquire auditory discrimination as early as the first day of life, as well as hear who is near them by the timbre (specific characteristics) of their voice (Brand, 1985). Between 4 and 6 months of age, infants become more attentive to musical sound by turning their head or facing toward the music source (Brand, 1985). Between 6 and 9 months of age, music babbling begins (Brand, 1985). This is defined as an infant making speech sounds on various pitches which are often accompanied by the infant moving to music and more often produced when someone sings to the infant. Between ten to eighteen months of age, infants begin physically responding to music, usually through hip swaying, bouncing, rocking, or clapping (Brand, 1985). Though research suggests, as will be reviewed below, that infants attend to and can discriminate music, no research was found on whether music can function as an aid to help infants learn.

Though introducing music to infants is entertaining and enjoyable, learning language is one of the most remarkable achievements in early childhood. Around 12-months of age, many infants are beginning to acquire new words, and around 18-months of age infants begin to experience a “vocabulary burst”, in which they develop a much faster rate of acquiring new words (Goldfield & Reznick, 1973). It is not until around the second year of life when infants' language abilities

dramatically improve (Bates, Bretherton, & Snyder, 1988). Around 24 months of age, infants typically produce 200 to 500 words (Fenson et al., 1994).

### *Gender differences in language*

Much research has been done indicating that infant/toddler girls have an early advantage than boys their same age in language acquisition. Preschool aged girls perform better on most aspects of verbal performance. This includes when they produce their first word(s), articulation, and sentence length (Maccoby, 1966). Research also indicates that girls acquire new words at a faster rate than boys during the two-year-old “vocabulary burst” (Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). Other studies that support these findings indicate that girls tend to produce words at an earlier age, have a larger vocabulary, and show higher level of language complexity beginning in early childhood (Hyde & Linn, 1988); as well as, toddler girls begin to talk sooner and more clearly than boys (Kimura, 2000).

### *Purpose of the study*

Infants begin to develop a concrete association between language learned and the things in their environment or word-object learning around 18 months of age (Baldwin et al., 1996). Though music may only seem to be an entertaining experience for infants, as will be reviewed below, infants are able to discriminate sound and show preferences in music. With much research attention centered around infant word-object learning, as well as infants and music, possible links between these two research categories should be investigated. The purpose of this study is to determine whether music can facilitate word-object learning in very young infants.

Given that girls are more advanced in language acquisition, a goal of the study was also to examine infant learning or word-object relations based on gender.

### Infant Learning Paradigms and Testing Procedures

Infant learning and behavioral responses are evaluated using learning paradigms. Learning paradigms are concepts primarily used during infant studies to both develop and test infants' understanding. Widely used infant learning paradigms include habituation, the head-turn preference procedure, and the conditioned head-turn procedure.

#### *Habituation*

Habituation is a technique widely utilized with young infants to help address a variety of questions concerning the early development of perception and cognition (Bornstein & Benasich, 1986). Habituation is a response that occurs whenever a stimulus is presented repeatedly to an infant. Initially, it is the amount of time infants display a discrete behavior such as looking at an object or event (Bornstein & Benasich, 1986). Repeated labeling and/or exposure to an unchanging condition should lead to the reduction in the discrete response from trial to trial. A decreased and/or loss of interest in the stimulus indicates that the infant has learned attributes of the object or event and has habituated. Typically, after the infant has habituated, presenting a new stimulus should lead to a renewed interest or response, such as increased looking to the new stimulus (Schoner & Thelen, 2006).

There are two types of habituation paradigms which are commonly practiced with infants. One is a fixed-trials version introduced by Fantz (1964) and the other is an infant-controlled version originated by Horowitz, Paden, Bhana, and Self (1972). In the fixed-trials version, the

experimenter determines the number, duration, and interval between exposures to stimulus, which is often independent of infants' attention (Fantz, 1964). In contrast, the infant-controlled version allows the infant to control these variables. In the infant-controlled version, the exposure or presentation of the stimulus does not end until the infant response behavior (e.g., looking) reaches a pre-determined criterion (Horowitz et al., 1972).

#### *Head-turn preference procedure*

The head-turn preference procedure (HPP) is a flexible testing procedure with the ability to be used with infants between 4 1/2 and 12 months of age. This procedure is used to test whether infants prefer one auditory stimulus over another. HPP is typically conducted in a three-sided booth to restrict infant's view. The procedure typically takes place in a dimly lit room. Loudspeakers are placed on opposite sides of each other within the booth. The center wall is usually blank with a colored light to regain infant's attention. Infants are seated in the booth in a appropriate seat or on their caregivers lap facing the blank wall and with a loudspeaker on either side of them. Trial phases are conducted by presenting two different kinds of stimuli to the infant. Looking times are evaluated and the calculations indicate which stimulus infants orient to longer (Kelmer-Nelson et al., 1995).

#### *Condition head-turn procedure*

A conditioned head-turn procedure is primarily used in testing auditory and speech perception in infants. When using this procedure, infants are taught to turn their head to a sound or to a change in sounds. The procedure takes place in a room with the infant sitting in their caregivers lap with an experimenter sitting across a table. The experimenter manipulates a toy to

help regain infant's attention throughout the experiment. A loudspeaker which sits on top of a dark plexiglass box is placed 90 degrees to the right or left side of the infant. A stimulus is presented over the speaker and the infant is taught to turn his/her head in the direction of the speaker whenever a change in the stimulus is detected. A toy is revealed in the plexiglass as reinforcement for correct responses. Incorrect head-turns are not reinforced. During the testing phase both the experimenter and the parent wear headphones delivering music to eliminate bias. The number of correct head-turns is calculated to determine infants' perception of speech and/or auditory stimulus (Werker, Polka, & Pegg, 1997).

### Infants Ability to Discriminate Music

#### *Discrimination of rhythmic patterns and change in tempo*

Infants as young as 7 months appear to attend to and discriminate characteristics of music. Eighty 7-to-9 month-old infants were presented with repetitions of three- or four-tone sequences which were characterized by a particular rhythmic structure. During a three-tone sequence presentation, infants were tested on their detection of a silent increment following the first tone (X XX) and second tone (XX X). In a four-tone sequence, infants were again tested on their detection of a silent increment following the second tone (XX XX) and third tone (XXX X) (Trehub & Thorpe, 1989). These sequences were also presented in different tempos. Infant were evaluated on their ability to detect change in the rhythmic structure and tempo using the conditioned head-turn procedure. The findings revealed that infants are capable of discriminating between contrasting rhythmic patterns and changes in tempo (Trehub & Thorpe, 1989).

### *Discrimination of well-structured and poorly-structured music*

Another study investigated infants' perception of good and bad music. Thirty 7-to-10-month old infants were tested on their ability to detect a semitone change in melodies using a conditioned head-turning task. Infants heard one of three melodies: a good (well-structured) Western melody, a bad (poorly-structured) Western melody, or a bad (poorly-structured) non-Western melody. Within each melody, a semitone change was made to the fourth note. Using a conditioned head-turn procedure, results indicated that infants were successful in discriminating the semitone changes in the good Western melody, but not in the bad Western and non-Western melody. These findings suggest that infants can detect interval changes in a well structured melody (Trehub, Thorpe & Trainor, 1990).

### *Discrimination of diatonic and non-diatonic changes in music*

Several studies using one of the above paradigms have shown that infants have the ability to discriminate specific aspects of music. In one particular study, 48 8- and 9-month-old infants and 28 adults between 18 and 32 years of age were tested on their ability to recognize changes in a 10-note melody. Half of the infants and adults heard a diatonic (subtle) change and the other half of both groups heard a non-diatonic (significant) change to the melody. The change was made to the sixth note of the melody. Results indicated that the adults could easily detect the non-diatonic change to the melody, but they had difficulty detecting the diatonic change; however, when using the conditioned head-turn procedure, results indicated that infants detected both changes equally. Findings from this study suggest that infants have the ability to recognize both major and minor note changes in a melody (Trainor & Trehub, 1992).

### *Music discrimination using prosodic features*

A more recent study supports yet another aspect in which infants discriminate music. In this study, 16 10-month-old infants were familiarized with two of four short musical excerpts all of which were taken from the same music. During the testing phase infants heard all four short musical excerpts. Infants were evaluated using a head-turn preference procedure, which indicated that infants listened longer to the familiarized musical excerpts than to the novel musical excerpts. These findings suggest that infants can use prosodic features to identify and remember particular musical performances (Palmer, Jungers & Jusczyk, 2001).

### Infant Listening Preferences

Along with infants' innate ability to perceive, distinguish, and remember musical aspects, they also display a range of listening preferences. A listening preference as it relates to developmental psychology is not favoring or liking one thing over another, rather it is demonstrating longer attention to stimuli, presumably because it is of interest (Kemler-Nelson, 1995).

### *Infants' basic listening preferences*

A study tested 16 two-day-old newborns' language preferences using a preference procedure. The newborns heard a recording of a stranger speaking in both Spanish and English. Infants heard the recording through headphones in which they controlled the presentation of the auditory stimulus through sucking on a nipple. Results indicated that infants sucked longer to activate the recordings of their native language than the foreign language. These findings

suggest that infants prefer to listen to their native language versus non-native languages (Moon, Cooper, & Fifer, 1993).

Twenty-four 2-to-8 month old infants completed an operant listening task which evaluated their preference for three auditory stimuli: their mother's voice, other female voices, and music. Infants were seated in an infant seat with a velcro strap placed around their ankle. The strap was connected to a switch which controlled the presentation of the stimulus. Infants manipulated the switch in order to hear certain stimuli. Results indicated that infants preferred to hear their mother's voice when compared to other female voices and music. Results also indicated infants' preference to hear music over other female voices. The findings in this study also suggest that the younger infants (2-to-5 months) preferred to hear their mother's voice, while the older infants (5-to-8 months) showed equal preference for both their mother's voice and other female voices. (Standley & Madsen, 1990).

Studies have also investigated infants' preference for motherese or infant-directed speech, which is a particular style of communication used with infants. This style can be described as "linguistically simplified and characterized by high pitch and exaggerated intonation" (Fernald, 1985). In an earlier study, 48 4-month-old infants were test in an operant auditory preference procedure. During the test procedure, infants went through 15 trials in which they heard two different recordings: mother-infant recording (motherese) and mother-adult recording. Using a modified version of the head-turn preference procedure, results indicated that 33 of the 48 infants turned more often toward the speaker that produced the motherese (mother-infant) recording than

toward the speaker that produced the adult-directed (mother-adult) recording. These findings suggest that infants prefer motherese over adult-directed speech (Fernald, 1985).

More recent experiments argue differently from previous studies. At least one recent study indicates that infant listening preferences are not determined by speech type (baby talk or adult-directed speech), rather they appear to be determined by the affect of the speech directed towards the infant (ie., happy, neutral, sad). Thirteen 6-month-old infants were investigated using the head-turn preference procedure. Infants went through 12 trials of hearing baby talk versus adult-directed speech. Results indicated that infants showed no significant difference in looking time between baby talk and adult-directed speech when both were presented in the same affect. Overall, irrespective of whether the adult used baby talk or adult-directed speech, infants preferred happy over neutral and neutral over sad speech (Singh & Morgan, & Best, 2002).

### *Infants' listening preferences in music*

Infants also show listening preferences in music. Thirty-two 4-month-old infants were investigated on their preference for pleasant and harmonic sounds (consonant) over clashing sounds (dissonant). Infants were seated in a room with a speaker placed at a 45 degree angle from where they were sitting. Infants heard the recording of both a consonant and dissonant version of a melody. Results were evaluated based upon the fixation time directed at the speaker. Results indicated that infants looked significantly longer at the speaker when the consonant version was heard, compared to the dissonant version of the melody. These findings suggest that infants prefer consonant versus dissonant music (Zentner & Kagan, 1998).

Another study tested sixty infants between 5-6 months of age on their preference for infant-directed or infant-absent singing. Infants heard the recording of a mother singing alone (infant-absent) and of a mother singing in the presence of her infant (infant-directed). Listening preferences were tested using the same design described in the previous study. Results indicated that infants looked longer at the toy that was associated with the infant-directed version and looked less at the toy that was associated with the infant-absent version of the mother's recording. These findings suggest that infants prefer to hear infant-directed over infant-absent singing (Trainor, 1996).

A study tested 16 infants (age average of 6-months) preference for high or low pitched singing. Infants heard the recording of a female singing a children's song in both high and low pitch range. A modified head-turn preference procedure was used for this study. Under each speaker was a toy which helped capture infants' attention. Results indicated that infants looked

longer at the toy associated with the high pitched recording than the toy associated with the low pitched recording. These findings suggest that infants prefer high-pitched over low-pitched singing (Trainor & Zacharias, 1998).

Another study evaluated infant listening preferences for the Prelude or Forlane from the musical piece *Le tombeau de Couperin* by Maurice Ravel. The Prelude is a piece of music that can stand alone or be used to introduce another movement of work. The Forlane is a fast past folk dance style of music. Preferences were evaluated using a head-turn preference procedure to test 30 8-month-old infants. Infants' showed a preference for the Prelude over the Forlane when it was played in multiple timbres (i.e. orchestral); however, infants showed no preference between the two when played in single timbres (ie. piano). These results suggest that infants can discriminate two different musical pieces with multiple elements of music (multiple timbres) but not single elements of music (single timbres). Within the same study, infants were exposed repeatedly to a piano piece over a 10-day period. Given a two-week delay, infants were still able to recognize the familiar musical piece. Concurrent with previous studies, infants demonstrate long-term memory for music (Ilari & Polka, 2006).

In a listening preference study, infants were tested on two versions of a novel Chinese children's song: unaccompanied (voice only) and accompanied (voice and instrumental background). Sixty infants within three age groups of 5-, 8-, and 11-months of age were tested using the head-turn preference procedure. Analyses from the study indicated that 5-month-olds and 11-month-olds listened longer during the experiment when compared to 8-month-olds. Results from the study indicated that 35 of the infants listened longer to the unaccompanied

rendition, eight of the infants listened equally to both renditions, and 17 of the infants listened longer to the accompanied rendition. Overall, findings suggest that infants showed a preference for the unaccompanied version of the song across age groups (Ilari & Sundara, 2009).

The results from these various studies taken together suggest that infants prefer and attend longer to more simplistic, pleasant, high-pitched songs/music. Infants can discriminate changes made to a melody, specifically a well-structured melody, and they prefer to hear their native language. Infants prefer to hear their mother's voice and they prefer to hear happy speech. Thus, in designing a study of which the musical aspect highly determines the outcome, the infants' preferences which have been discussed above need to be considered to create an optimal musical experience for infant learning. Creating an optimal musical experience is expected to increase infant's attention and learning ability.

## Word-Object Learning

### *Defining word-object learning*

Word-object association is how infants explore and actively learn the name for objects and events in their everyday environment. Essentially, it is learning which words and objects "go together" or simply the realization that a word can "stand for" an object (Reznick & Goldfield, 1992).

### *Word-object learning under socially supportive conditions*

An early study that assessed infant word-object learning in a supportive environment, explored infants' ability to develop and comprehend word-object association (Oviatt, 1982).

Thirty infants ranging in age between 9 and 17 months old participated: ten 9-11 month olds, ten 12-14 month olds, and ten 15-17 month olds. Infants were placed in a natural setting and given an allotted amount of time to actively explore a novel object (a rabbit) while an adult labeled the object. Following a demonstration phase, infants were shown two objects: 1) the familiar object and 2) a new object. Infant comprehension was tested using a probe question (e.g., “Where is the rabbit?”). Results indicated that after the distraction phase only one of the ten 9-11 month olds successfully recognized the familiar object, indicated by longer looking. Five of the ten 12-14 month olds correctly identified the familiar object, and eight of the ten 15-17 month olds successfully identified the familiar object. These findings suggest that around 15 months of age, infants begin to develop word-object association (Oviatt, 1982).

Another study investigated infants’ ability to recognize a labeled novel object in three different representational modes: photographic, pictorial, and three-dimensional. Twenty-one 12-to-20-month old infants saw a live animal (a hamster) which was unfamiliar to them while hearing it being labeled. The infants were allotted time to actively explore the hamster in a transparent cage while it was being labeled. Comprehension was tested through evaluating infants preferential gazing and gestural response to probing statements such as “Where’s the hamster?” or “Pat the rabbit?”. Results revealed no evidence of infant word-object association between 12-15 months of age; however, 18-20 month old infants demonstrated a significantly better understanding of the hamster being labeled, suggesting that by 1 1/2 years of age infants may be learning the word for animated objects like animals (Oviatt, 1982).

A study by Baldwin et al. (1996) also investigated infants' word-object learning abilities under a natural and social setting. The experiment investigated whether infants rely on social criterion, such as joint attention and/or infant-adult interactions to establish word-object relation. Sixteen 15-to-17 month olds and sixteen 18-to-20 month olds participated in the study. Infants were placed in a playroom and presented with five objects to actively explore. Three of the objects were familiar and two were novel. Infants heard each of the novel objects being labeled "toma" or "peri" under one of two conditions — coupled and decoupled. An object being labeled under coupled conditions include the experimenter being within the infant's view and looking at the object while the infant actively explored the object. A decoupled condition involved the experimenter labeling the novel object while standing behind an opaque, restricting the infant's view of the person labeling the object (Baldwin et al., 1996).

Infant comprehension was determined by coding infants' responses to probe statements (e.g., "Show Mama/Daddy the peri!") and comprehension questions (e.g., "Can you point to the toma?"). Results indicated that 15-17 month olds showed no significant differences in the coupled versus the decoupled conditions. When the novel object was labeled under the coupled condition, 15-17 month olds correctly identified the novel object 53% of the time. When the novel object was labeled under the decoupled condition, 15-17 month olds successfully identified the object 44% of the time. In contrast, 18-20 month old infants were able to correctly identify the novel object 77% of the time when labeled under the coupled condition, and 48% of the time when labeled under the decoupled condition. In both age groups none of the infants showed high levels of comprehension when objects were being labeled under the decoupled

condition. The findings suggest that infants between 15-17 months of age are unable to fully and successfully develop a word-object association without social criterion. Results also suggest that by 18-20 months of age infants demonstrate a more stable comprehension of word object learning, given social criterion (Baldwin et al., 1996).

*Word-learning under tightly controlled conditions*

Another study examined whether infants could learn word-object association in the absence of social cues. Thirty-two 14-month-old infants were placed in a small and dim laboratory room while seated in their caregiver's lap. During a training phase, infants heard an audio recording of someone labeling two different novel objects while the object was presented on a monitor. The experimenter measured infant's attention and comprehension using the habituation paradigm. Comprehension was also tested using the habituation paradigm. During the testing phase the experimenter switched the labels; meaning the object the infant viewed no longer matched the label provided during the training phase. If infants habituated, that is learned the word-object pairing, they were expected to notice a mismatch of the label and object being presented. Results indicated that 14-month-old infants recognized the mismatch word-object pairing by greater looking during the test trail, which is an indication that they learned the word-object pairing (Stager et al., 1998).

Another study also explored infants' ability to develop word-object pairing under controlled conditions (Schafer & Plunkett, 1998). Twenty-nine 12-to-17 month-old infants were placed in a dim laboratory room while sitting in their caregivers lap and facing a monitor. Infants were presented and trained on two novel images, with a novel word ("bard" or "sarl") associated with

each image. Each object was correctly labeled a number of times. During the testing phase both novel objects were presented to the infant, along with a word: one of the novel words (“bard” or “sarl”) heard during the training phase, or an additional word (“geek”) that had no association to either of the novel images they were trained on. Infants’ comprehension of these novel objects was measured by a preferential looking test, to examine if infants would look longer at the image they believed matched the novel word which was heard. Results indicated that infants had the tendency to look towards the image that correctly matched the label being heard, than to the image that created an incorrect match; however, only a trend was observed suggesting that infants have not mastered word-object learning prior to 1 1/2 years of age (Schafer & Plunkett, 1998).

Other studies indicate that word-object relations can be learned as early as 6-7 months of age using maternal naming. Maternal naming is a semi-structured short play episode in which a mother labels a novel object for her infant (Matatyaho & Gogate, 2008). One study investigated what exactly made maternal naming effective (Gogate & Betancourt, 2006). Twenty-four mothers and their 6-8 month old infants were used for the study. Following 5 minutes of free play for the infant, the mothers were given a 3 minute play episode to label two objects with novel words for their infant (1.5 minutes on each toy). The objects were a Martian and a raccoon and the two novel words were *Chi* and *Gow*. Infants were tested and evaluated on their understanding for the two word-object relations using the proportion of infants first look (PFL) to the object that matched the label. This was calculated by dividing the number of trial infants correctly looked first to the object that matched the label by the total number of trials. Results

indicated that the mothers' use of temporal (visual) synchrony between spoken words and the motions of the object influenced infants' ability to learn word-object relations. That is, when mothers moved the objects in synchrony with the spoken word, infants learned the word-object relations. Results also indicated that infants switched their gaze from their mother to the object when temporal synchrony was used. Infant's gaze switching facilitated the infant's learning of word-object relations. Given these results, the findings suggest that pre-verbal infants (6-8 months of age) are able to learn word-object relations under specific conditions, such as synchronizing the motion of the object and words spoken (Gogate & Betancourt, 2006).

Another study replicates design of the previous study to discover what kinds of synchronous motions should be used to grasp the infant's attention when labeling a novel object (Matayaho & Gogate, 2008). In this replication study, 24 mothers and their 6-8 month old infants participated. Using the same procedure described above, mother were given a 3 minute play episode to label the two toys. Analyses of the play episode indicated that shaking and moving the toy in a forwards and backwards motions was more frequently used during synchronous than asynchronous naming. Results also indicated that moving the object in synchrony with its name provides redundancy making the relationship more noticeable. These findings suggest that preverbal infants are sensitive to object motions such as shaking and that specific object motions that occur in synchrony with words spoken facilitate young-infants learning word-object relations (Matayaho & Gogate, 2008).

## EXPERIMENTAL STUDY

### *Problem statement and hypothesis*

Though previous research has explored infant word-object learning abilities as well as infants' memory, discrimination, and preference for music, no research was found that investigated whether music/songs can facilitate infants' word-object learning. The purpose of this study is to examine if labeling objects through song while using synchronous object movements will facilitate infants' memory for word-object association at 6-months of age — a younger age for word-object acquisition than reported in previous studies. Previous studies by Gogate and colleagues which are discussed above have been considered when determining the age group of the participants. These studies revealed that infants are capable of learning word-object associations when accompanied with synchronous movement.

## METHODOLOGY

### *Participants*

Due to more recent research that has explored the possibility of word-object learning at a younger age of 6-months, the design of this study is to expand upon the work of Gogate and her colleagues (2008) who introduced word-object learning at this age. Sixteen infants between the age of 6-to-8 month completed the testing; however, the average age of the infants who participated in this study was 223.56 days old (7½ months), with a range of 184-262 days old. Background data (e.g., infant age, gender, race, etc) were analyzed using chi-square and ANOVAs to compare the two groups at the start of the study. The two groups did not differ on age,  $t(14) = .30, p > .05$ . Chi square analysis revealed a gender difference by condition  $\chi^2 =$

4.27,  $p = .039$ . More girls participated in the song condition (song  $N = 7$ , spoken  $N = 3$ ) than in the spoken. Overall, there were more white ( $N = 14$ ) infants than black; however, race did not differ between the two conditions  $\chi^2 = 0$ ,  $p = .05$ . Infants had been randomly assigned to the conditions (ie., spoken or song word-object learning) and no stratification had been made prior to control for race or gender of infant.

Eight infants received the stimuli under a music condition and the other 8 received the stimuli under a speech condition. All infants were healthy, and free of ear infections as reported by caregivers. Infants came from English-speaking families and were accompanied by their primary caregivers. Parental consent was gained prior to conducting the study.

### *Stimuli*

An audio-video recording presenting two novel objects was made. Each object moving in synchrony to the sound of a non-sense word (object A/"tib" and object B/"pax"). Refer to Figure 1 for an illustration of the objects. Infants in the music condition were presented an audio-video recording of both objects being labeled through song with continuous repetition of the word. Infants in the speech condition were also presented an audio-video recording of the same objects being labeled through speech, using the same repetitive speech. A female fluent in English recorded all the labels for the objects in synchrony with words spoken or sung. The speaker was instructed to imagine that she was speaking/singing to an infant to ensure appropriate infant-directed speech and prosodic contours. Several recordings were made and a final selection was carefully decided upon based on prosody.

Figure 1

Objects used for labeling



### *Apparatus*

The training and testing phase of the study took place inside a small, quiet, and dimly lit laboratory room in the Department of Human Development and Family Studies at the University of Alabama. Inside the laboratory room was a 1.2m x 1.2m four-sided black booth. Black curtains were hung on two sides of the booth opposite from one another to restrict infants' view of the rest of the room. The third wall which faced the infant was covered with all black poster board with a peep hole located on the top right corner and two peep holes located in the middle. The fourth side which is also the back of the box was left open to easily access the infant and for the experimenter to project the videos.

Two experimenters conducted this study. Experimenter #1 used the peep holes to observe and code infant's looking behavior. The middle peepholes were used to record the infants' looking using a camera and video recording which was already stationed in an observation room next door. Experimenter #2 controlled the stimuli being presented. Experimenter #1 and #2 reviewed all video recordings at the end of the study and coded all videos. Experimenter 1 was the primary observer and was blind to the correct object-word matching side. Experimenter #2

served as the projectionist or video presenter and her observations from the videos at the end of the study served for reliability purposes.

The video segment for each trial was synchronized with the correct audio stimuli using Final Cut Pro computer program. Signals were transmitted to the monitor(s) and speakers, concurrently. During the habituation (training) phase, infants were seated in a baby seat that was in viewing distance from the recording camera and one 19-in color monitor (ViewSonic VX1935mn) that produced the visual stimuli. Two small Dell speakers were placed next to each other directly under the booth and in between the computer monitors. The small Dell speakers provided the audio stimuli (Refer to Figure 2 for an illustration). During the testing phase infants were seated away and equidistant from two adjacent 19-in color monitors, as well as in a visual screen shot of the recording camera. Again, the Dell speakers were centered directly under the booth through which the audio stimuli were played (Refer to Figure 3 for an illustration). In both the habituation and the testing phases, the video camera lens was moved to capture the infants' full face. The computer monitor was reflected as a small light in the infant's pupil when the infant looked at the computer monitor, which was how infant looking to the monitor was determined.

As stated above, experimenter #1 monitored the infant's visual gaze on the monitor using the peep hole during the training phase. Experimenter #1 manually recorded the duration of infant gazing during habituation using a timer that recorded milliseconds. Experimenter #1 also controlled the infants viewing of the stimuli by pressing a button to switch the monitor(s) on and pressing the same button to turn the monitor(s) off when the infant reached on a habituation trial

either 60 seconds of looking or 2 seconds of looking away from the monitor. The turning off of the monitor signaled to Experimenter #2 when to end each trial as it indicated that the infant had looked away for the 2 second criterion or had accrued 60 seconds of looking on that trial. Thus, two criteria were used to terminate the habituation trials: 1) 60 seconds of accrued looking to the computer monitor or 2) two consecutive seconds of not looking at the computer monitor.

Experimenter #2 responded to this signal by temporarily pausing the stimulus/stimuli from being presented. Once Experimenter #2 had paused, nodded to Experimenter #1 who saw her through the peephole, Experimenter #1 then pressed the button to turn the monitor(s) back on which also indicated to experimenter #2 to continue playing the video.

ILLUSTRATION 1

Habituation Phase

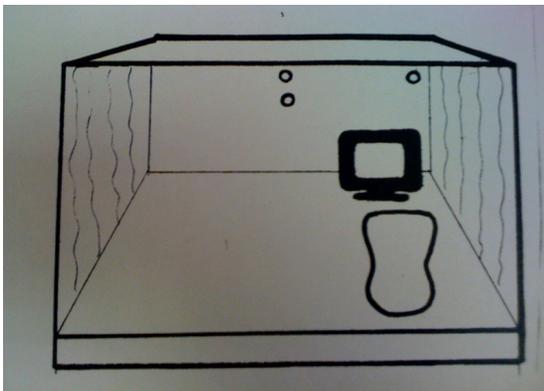
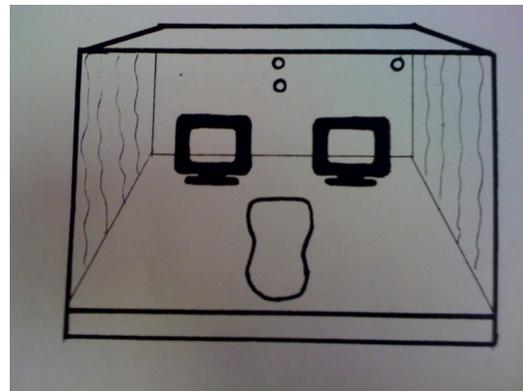


ILLUSTRATION 2

Test trials



### *Procedure*

Infants were trained and tested using an infant-controlled habituation procedure. Half of the infants were randomly assigned to the music condition and half to the speech condition. Infants within each condition received the stimuli described above, respective of the appropriate category. Each infant habituated to an alternating sequence of the “*Tib*” and “*Pax*” audio recordings which were matched to a panda bear or a worm. Half of the infants received the panda bear- “*Tib*”/worm- “*Pax*” audio-visual recordings and the other half received the reverse order (ie., panda bear- “*Pax*”/worm- “*Tib*”).

The habituation procedure consisted of six mandatory habituation trials, and was terminated after the infant has reached the habituation criterion of a 50% decrement in visual fixation level on two consecutive trials, relative to the infant’s initial fixation level on the first two habituation trials. The requirement to have a 50% decrement in visual fixation for two consecutive trials serves to establish a more conservative criterion for habituation by reducing chance habituation.

Following habituation, the infant remained in the seat, but was turned away from the monitors for a 2-minute delay which was used to stage the testing phase of the study. Once the testing phase was set up, the second monitor was revealed from behind a black board and the infant was turned and positioned between the two test monitors. The black curtains were drawn so that the infant was surrounded by two black walls (one to the right and one to the left) and the computer monitors directly in front. The test trials began using the physical set-up previously described and depicted in Figure 3. The objects were presented side by side across two blocks of six trials (Block 1: trials 1-6; Block 2: trials 7-12). The same audio stimulus (song or speech) that

was presented during the habituation phase was presented again simultaneously with still visual stimuli (e.g. the objects). The stimuli for the test phase were still so that synchrony did not direct infant looking. The audio recording was played in random order with the restriction that no recording be played more than twice in succession and each of the two stimuli be played equal amount of times (ie., 3 times each) within each block. For counterbalance, the lateral positions of the two objects were switched. For example, if during the first block of trials the panda bear appeared on the right-hand screen and the worm appeared on the left. The reverse arrangement appeared during the second block of trials.

## *Results*

### *Habituation*

Descriptive statistics were conducted to compute the average seconds to reach habituation and the average number of trials to reach habituation for each group (the spoken and song conditions). A One-Way ANOVA was conducted to examine whether the two groups differed on the habituation measures. The groups did not differ on any measures. Mean looking times of the study are displayed in Table 1.

TABLE 1

Habituation measure between groups: Means (&amp; standard deviations) and ranges

Variables	Song	Spoken	F	<i>p</i>
Baseline secs. (1+2/2)	24.1(19.4)	20(12.7)	.25	.62
Criterion (baseline/2)	12(9.7)	10(6.3)	.25	.62
Habituation secs.	110.8 (80.3)	133.5(110.5)	.22	.65
Number of trials to habituate	6.8(2.8)	6.6(1.4)	.01	.91
Baseline (min to max)	(8.5-60)	(5-38.50)		
Criterion (min to max)	(4.25-30)	(2.50- 19.25)		
Habituation secs. (min to max)	(47-275)	(21-325)		
Trials to habituation (min to max)	(4-12)	(5-9)		

*Primary analyses**Test trials*

The total number of seconds looking to the correct object (i.e., word-object match) over the total number of seconds of looking was computed for each trial. Then proportions of looking to the matching object was computed for the first 6 trials (Block 1), for trials 7-12 (Block 2) and across trials 1-12. The three proportions of looking time or PTLs for Block 1, Block 2, and Block 1+2 served as the dependent measure and was tested against a chance value of .50 (50%) using a one-sample t-test. If infants learned the word-object relation, the PTLs were expected to differ significantly from 50%. In other words, infants were expected across the test trial blocks

to look longer to the computer monitor that displayed the object that matched the audio being played. When compared to chance, infants within the spoken condition significantly looked longer to the incorrect word-object pair on 1) Block 2 (M= .43, SD= .09),  $t(6) = 2.29, p = .03$ ; and 2) across both Blocks (M= .45, SD = .04),  $t(6) = 2.76, p = .017$  (one-tailed). One tailed p-values were used because the direction of looking was predicted a priori. There were no significant findings for PTL within the song condition when compared to chance.

An ANOVA was also conducted to examine if the proportion of total looking time (PTL) to the correct word-object pair differed between the song and the spoken group. There was a significant difference between the two conditions in the mean PTL to the correct word-object pair in block 2 and a marginal difference in PTL to the correct word-object pair across both blocks (See table 2).

TABLE 2

Test trials: Mean proportion of looking time (PTL) and standard deviations (SD) on test trials for the Song and the Spoken conditions on Block 1, Block 2, and across the 12 trials (Block 1 and 2)

Variables	Song	Spoken	F	<i>p</i>
Block 1 (1-6)	.46(.09)	.48(.03)	.30	.30
Block 2 (7-12)	.51(.06)	.43(.09)	4.06	.03
Block 1+2 (1-12)	.49(.03)	.45(.04)	2.20	.08

*Infants' first looks*

In addition to the proportions of looking time to the correct object, infants' first look to the correct object was computed as a secondary measure of interest. In the test trials, the visual stimuli remained in the same location for trials 1-6 and switched for trials 7-12, while an audio track which randomly labels "*Tib*" or the "*Pax*" was played. Thus, if infants learned the word-object pair, and the visual stimuli did not change sides, there should be a greater chance that they will look first to the correct video side when they heard the sound track on each trial, except perhaps the first trial where they have not yet learned the position of the two stimuli. First looks are standard secondary measures in the infant literature and provide a measure of confirmation of learning (Gogate, Bolzani, & Betancourt, 2006). An ANOVA was conducted to examine if infants first look to the correct word-object pair differed between the two conditions. There were significant performance differences on 1) Block 1  $p = .064$ , Block 2  $p = .008$ , as well as across both Blocks  $p = .02$ .

When compared to chance (ie., 50%) for the spoken condition, infants' first look were significantly more to the incorrect word-object pair on 1) Block 2 ( $M = .40$ ,  $SD = .13$ ),  $t(6) = 1.94$ ,  $p = .05$ ; and 2) across both Blocks ( $M = .43$ ,  $SD = .06$ ),  $t(6) = 3.33$ ,  $p = .008$ , along with a marginal difference for Block 1 ( $M = .45$ ,  $SD = .08$ ),  $t(6) = 1.54$ ,  $p = .086$ . When compared to chance for the song condition, infants' first look were significantly more to the correct word-object pair on 1) Block 2 ( $M = .64$ ,  $SD = .16$ ),  $t(5) = 2.09$ ,  $p = .045$ ; and 2) across both Blocks ( $M = .61$ ,  $SD = .11$ ),  $t(5) = 2.38$ ,  $p = .03$ .

#### *Gender analyses*

The background data analyses revealed there were more girls assigned to the song condition than to the spoken condition, which happened by chance since infants were randomly assigned to the conditions and we did not stratify for gender. An ANOVA was conducted to examine possible gender effects. The analysis revealed: 1) girls ( $M = 0.50$ ,  $SD = 0.06$ ), differed from boys ( $M = 0.41$ ,  $SD = 0.09$ ), on PTL scores to the correct word-object pair on Block 2,  $F(1,12) = 4.85$ ,  $p = 0.05$ ; 2) girls' ( $M = 0.48$ ,  $SD = 0.03$ ), more than boys' ( $M = 0.44$ ,  $SD = 0.04$ ), PTL scores were marginally more to the correct word-object pair across both Blocks  $F(1,12) = 3.58$ ,  $p = 0.085$ ; 3) girls' ( $M = 0.58$ ,  $SD = 0.18$ ), more than boys' ( $M = 0.40$ ,  $SD = 0.15$ ), first look tended to be marginally more to the correct word-object pair on Block 2  $F(1,12) = 3.65$ ,  $p = 0.08$ ; 4) girls' ( $M = 0.57$ ,  $SD = 0.12$ ), more than boys' ( $M = 0.42$ ,  $SD = 0.06$ ), first looks tended to be significantly more to the correct word-object pair across both Blocks,  $F(1,12) = 7.06$ ,  $p = 0.02$ .

### *Discussion*

As hypothesized, results indicate that singing versus speaking affects young infants' learning of word-object relations. In the current study, singing words to infants related to greater looking to the correct word-object pair than spoken words for objects. When comparing the condition groups to one another, infants within the song condition looked longer than infants within the spoken condition to the correct word-object pair. Albeit, initially it appeared that neither group learned the word-object pairs since the proportion of total looking to the correct word-object relation at best bordered around the 50% level for the singing condition.

A closer inspection of the data revealed that when compared to chance (50%), infants in the spoken condition looked significantly longer to the incorrect word-object pair for the last six

trials of the test (Block 2), and when all trials were averaged (Block 1+2/2). Also when compared to chance, infants within the spoken condition first look was significantly more to the incorrect word-object pair on the last six test trials (Block 2) and when all trials were averaged (Block 1+2/2), as well as a marginal difference for the first six trials (Block 1). In contrast, infants within the song condition first looks were significantly more to the correct word-object pair for Block 2 and across both Blocks; First looks were in the 60% and higher range, which gave us confidence that the song group showed evidence of word-object learning.

The random assignment of infants to condition in this study resulted in more girls participating in the song condition, which was unintended. Girls significantly spent more time looking at the correct word-object pair than boys for Block 2 of the test trials, and marginally greater looking to the correct word-object pair difference across both Blocks. Girls' first looks were also significantly more to the correct word-object pair than boys across both Blocks, with a marginal difference for Block 2. It is a strong possibility that the gender effects within this study are due to condition assignment, because more girls than boys were assigned to the condition in which better performance was expected; however, it is also possible that girls learned the word for objects better than boys.

As stated previously, research indicates that gender differences are found in verbal, language, and certain spatial skills. Girls begin to produce words at an earlier age, improve articulation, have a larger vocabulary, and show higher level of language complexity earlier than boys (Hyde & Linn, 1988; Maccoby, 1996). The average 20-month old girl has twice the vocabulary than boys of the same age. Toddler girls begin to talk sooner and more clearly than

boys (Kimura, 2000). Thus, perhaps it is not surprising that girls outperformed infant boys in a word-learning task.

Gender differences are not uncommon, particularly in language development; however, the only way to confirm or dispute whether the gender differences reported in study this are accurate, would be to duplicate this study and determine whether performance differences still exist when the assignment to condition are equal for gender and with a larger sample size.

Most of the significant findings from this study occurred within Block 2 of the test trials, as well as when all trials were considered (Blocks 1+2). This phenomenon has been previously reported in other infant studies (Bahrick, 2002; Bahrick, Netto & Hernandez-Reif, 1998; Walker-Andrews, Bahrick, Raglioni, & Diaz, 1991). Perhaps, under some conditions it takes young infants a block of trials to figure out the task of looking to the correct object that matches the word they hear. Or, perhaps, switching the right and left placement of the objects on Block 2 heightens the infants' awareness of the task. In any event, the findings suggest that infants who were habituated to objects where words for the objects were sung in synchrony, learned the relationship between the words and objects better than when the words for the objects were spoken. In our review of the literature, this is the first time that this phenomenon has been reported.

There is much research identifying aspects of infant natural listening preferences for both speech and music. For example, prior research report that infants prefer consonant (Zentner & Kagan, 1998), infant-directed (Trainor, 1996), high-pitched (Trainor & Zacharias, 1998), and unaccompanied singing/songs (Illari & Sundara, 2009). In the current study, all of these infant

preferences were incorporated in an effort to obtain optimal infant attention and to examine if infants could learn word-object relations through song at an earlier age than reported in the literature.

Earlier research suggested that when objects are labeled within a natural play/social setting, infants developed word-object association at 15-to-20 months of age (Oviatt, 1982). Even in very similar settings, other studies suggest that infant development of word-object relationships doesn't occur until a little later at 18-to-20 months of age (Baldwin et al., 1996). Recent studies not only propose that infants can acquire the same skills in tightly controlled (non-social/play) settings, but also at a much younger age. Infants as young as 6-to-8 months of age are able to develop word-object relations given specific criteria such as maternal labeling and synchronous motions (Gogate & Betancourt, 2006).

As discussed, infants have preferences for musical aspects, but music also plays a powerful role in memory. Infants as young as 8-months of age are able to show recognition of a familiar piece of music, even after a two-week delay (Illari & Polka, 2006). It is possible that incorporating these preferences resulted in greater learning for the word-object pairs. Though neither group significantly differed in the amount of time taken to reach habituation, something happened by which greater learning took place within the song condition, in the same amount of time taken within the speech condition. Incorporating infant listening preferences can encourage early perception of word-object relations for infants.

The current study supports that presenting word-object relationships through song influenced infant learning, at least in terms of infant looking preferences. One implication is that

incorporating infant listening preferences, such as singing to infants, can promote early perceptual learning for infants. Infants naturally exhibit a preference and memory for music. Integrating language with infant preference for music, has the potential to increase language acquisition for infants.

Long before now parents, preschool teachers, and children television programs have been incorporating songs as a form of teaching and learning with mostly anecdotal support their actions. This study supports the anecdotal use of songs as a form of teaching and learning in infancy. Much research is still needed to examine how best to incorporate songs in young children's curriculum. For example, research is needed to examine if songs should incorporate as many aspects of infant music listening preferences as possible, such as using consonant music that is high-pitched, infant directed and unaccompanied. Using song as a form of teaching and learning without such consideration may not produce the same results.

This particular research examined using song for teaching and learning word-object pairs; however; the findings of this study open up the door for using songs for many other developmental and learning purposes. Parents and teachers may incorporate infant preferences and memory for music to teach counting/number recognition "Five Little Monkeys", or teach patterns/sequence, "Old McDonald Had a Farm". Songs can also be used to exam infant learning of such things as the names of important individuals (e.g., caregivers peers, sibling, pets) or relevant items in their environment (e.g., their crib, spoon, bottle, car, etc).

### *Limitations and future studies*

The small sample size of the study is a potential limitation. However, even with just 8 infants in the song condition and 8 in the spoken condition, differences were found suggesting that singing words influences infant learning of word-object relations over merely speaking words. Before this finding can be affirmed, it has to be replicated with a larger sample size. Another limitation is that we did not control for gender and by chance, because the participants were randomly assigned to the conditions of the study, we ended up with more girls in the song condition than in the spoken condition. The gender findings suggested that girls carried the effects of learning the word-object relation in the song condition. Although, it could also be interpreted as that girls learned the words for objects that were sung. This finding also needs to be replicated and further investigated. At least one study has reported that the left hemisphere of the brain is more developed at six months for infant girls than for infant boys and this may in part explain the gender difference in the current study (Shucard & Shucard, 1990), along with literature suggesting that girls acquire language prior to boys (Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991).

No reports indicated a significant difference in the amount of exposure to the stimuli between the two conditions or between the two genders. Only proportions of first looks achieved significance in the study and this was most evident at the end of the testing phase (i.e., the 2<sup>nd</sup> block of trials). There is a possibility that exposure time could affect infants learning of word-object relations. Perhaps, better performance for learning through song would have been achieved if infants had a fixed trials procedure with longer exposure to the word-object relations.

This should be explored in a future study. Another future study might control for word-object learning when the sung word is synchronized as opposed to asynchronous. It is likely that like in the Gogate, Bolzani, and Betancourt (2006) study, infant learning for word-object relations will need to be synchronized even when the word is sung. However, this is an empirical question and needs to be tested. Other controls that should be explored include infant learning preferences such as the pitch of the song.

### *Implications*

In our review of the literature, this is the first study to suggest that infants may learn words for objects better when the word is sung than just spoken. If this finding is replicated, one implication is to suggest to caregivers and preschool teachers of young children to sing when teaching 6-to-8 month old infants words for objects. As previously discussed, incorporating song does not have to be limited to only labeling word-object relations, but can be extended to other various forms of teaching and learning, from patterns and number recognition, to identifying items and events in their daily environment.

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