How Stimulus Relations Accrue for the Names of Things in Preschoolers

Frank A. Frias

Submitted in partial fulfillment of the
Requirements for the degree of
Doctor of Philosophy
under the Executive Committee
of the Graduate School of Arts and Sciences

COLUMBIA UNIVERSITY

2017
ABSTRACT

How Stimulus Relations Accrue for the Names of Things in Preschoolers

Frank A. Frias

In a demonstration study, Experiment I compared the naming cusp and capability for auditory, tactile, and olfactory stimuli with 6 preschool-aged children who demonstrated the naming capability for visual stimuli. Probes for listener and speaker responses were conducted following separate stimulus-stimulus pairings during which the experimenter presented a stimulus from one of the four modalities (i.e., visual, auditory, tactile, or olfactory) for the participant to observe, and named the stimulus. The names of the stimuli were counterbalanced, such that the names of each of the stimuli within each modality (e.g., visual modality) had different assigned names than the stimuli in the other modalities (e.g., auditory, tactile, and olfactory modalities). Four of the participants in Experiment I were typically developing and two participants were diagnosed with an Autism Spectrum Disorder. Five of the participants demonstrated full naming (i.e. the emission of untaught listener and speaker responses) for visual stimuli and at least 1 other stimulus modality after 2 sessions of stimulus-stimulus pairings of stimuli and their names (i.e., naming experiences). One participant only demonstrated the listener half of naming for visual stimuli and did not demonstrate naming for any of the other stimulus modalities tested. Naming accrued for one or more stimulus modalities for five of the six participants after the second naming experience. Previous research investigating naming for a stimulus modality other than visual have demonstrated the acquisition of naming for auditory stimuli following stimulus-stimulus pairings of visual stimuli with auditory stimuli presented with the same name. In Experiment II, I used a delayed repeated probe
design across three dyads to test the effects of repeated stimulus-stimulus pairings across visual, auditory, tactile, and olfactory stimuli, presented simultaneously, with 1 name assigned for each modality set, on demonstrations of naming. In Experiment II the naming experiences consisted of the simultaneous presentation of four stimuli (i.e., visual, auditory, tactile, and olfactory) while the experimenter labeled each stimulus while the participant observed. Five of the participants demonstrated overall increases in correct untaught speaker responses following the repeated stimulus-stimulus pairings. Some participants demonstrated decreases in correct responses across sessions, indicating certain stimuli elicited avoidance responses after repeated exposures and affected the acquisition of some of the stimulus names. Five participants also demonstrated transfer of stimulus control from visual stimuli to one or more of the other stimulus modalities, indicating higher-order conditioning occurred. The findings provide further evidence for the differential development of naming across stimulus modalities for children with visual naming through stimulus-stimulus pairings.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF TABLES</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>v</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LIST OF FIGURES</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>vii</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACKNOWLEDGMENTS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>viii</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DEDICATION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ix</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER 1- INTRODUCTION AND REVIEW OF THE LITERATURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Observing Responses and Conditioned Reinforcement</td>
<td>5</td>
</tr>
<tr>
<td>Stimulus Control</td>
<td>6</td>
</tr>
<tr>
<td>Unconditioned and Conditioned Sensory Observing Responses</td>
<td>8</td>
</tr>
<tr>
<td>Somatosensory (tactile) observing responses.</td>
<td>10</td>
</tr>
<tr>
<td>Olfactory observing responses.</td>
<td>12</td>
</tr>
<tr>
<td>Auditory observing responses.</td>
<td>14</td>
</tr>
<tr>
<td>Visual observing responses.</td>
<td>16</td>
</tr>
<tr>
<td>Research on the Identification and Establishment of Pre-verbal Foundational Cusps</td>
<td>17</td>
</tr>
<tr>
<td>Behavior Analytic Theories of Equivalence and Language Acquisition</td>
<td>19</td>
</tr>
<tr>
<td>Stimulus equivalence.</td>
<td>19</td>
</tr>
<tr>
<td>Relational frame theory (RFT).</td>
<td>21</td>
</tr>
<tr>
<td>Verbal behavior developmental theory (VBDT).</td>
<td>23</td>
</tr>
<tr>
<td>Stimulus Equivalence and Cross-modal Equivalence Relations</td>
<td>24</td>
</tr>
<tr>
<td>Naming Research</td>
<td>25</td>
</tr>
</tbody>
</table>
Interventions to Induce Naming....................................................................................... 26
  Multiple exemplar instruction (MEI)........................................................................ 26
Educational Significance and Rationale for the Present Experiments...................... 29
CHAPTER II.................................................................................................................. 32
Method ............................................................................................................................ 32
Participants.................................................................................................................... 32
Materials ....................................................................................................................... 34
Design ........................................................................................................................... 39
Procedure ....................................................................................................................... 40
  Naming experiences................................................................................................... 40
  Probes for naming...................................................................................................... 41
Probe Procedures ......................................................................................................... 42
  Listener responses to visual stimuli......................................................................... 42
  Speaker responses to visual stimuli ....................................................................... 42
  Listener responses to tactile stimuli....................................................................... 42
  Speaker responses to tactile stimuli....................................................................... 43
  Listener responses to auditory stimuli.................................................................... 43
  Speaker responses to auditory stimuli.................................................................... 43
  Listener responses to olfactory stimuli................................................................... 43
  Speaker responses to olfactory stimuli................................................................... 44
Data Collection............................................................................................................ 44
Interobserver Agreement ............................................................................................. 45
Results.......................................................................................................................... 45
Summary of Findings............................................................................................................. 89
Conditioned Reinforcement and Naming ............................................................................. 92
Blocking Effect..................................................................................................................... 93
Educational Implications of Findings .................................................................................. 94
Limitations and Future Research ......................................................................................... 94
Conclusion ........................................................................................................................... 97
REFERENCES ...................................................................................................................... 89
LIST OF TABLES

Table 1. Participant characteristics for Experiment I.................................................. 33

Table 2. Stimulus modalities and contrived names assigned to each participant for Experiment I................................................................. 40

Table 3. Stimulus modalities and contrived names assigned to each participant for Experiment I................................................................. 40

Table 4. Interobserver agreement (IOA) conducted for Experiment I............... 45

Table 5. Number of correct/total listener and speaker responses emitted by participants across four stimulus modalities following initial naming experience. ................................................................. 47

Table 6. Participants' number of correct/total listener and speaker responses emitted during both probe sessions across four stimulus modalities. ............... 48

Table 7. Contrived alchemy symbols used during stimulus-stimulus pairings and probe sessions ................................................................. 59

Table 8. Tactile stimuli used during stimulus-stimulus pairings and probe sessions ......................................................................................... 60

Table 9. Olfactory stimuli (essential oils) used during stimulus-stimulus pairings and probe sessions................................................................. 61

Table 10. Contrived two-syllable, phonemically transparent words used during stimulus-stimulus pairings and probe sessions ............................. 62
Table 11. Example of a set of stimuli and contrived names used during stimulus-stimulus pairings and probe sessions for one participant................................ 64

Table 12. Interobserver agreement (IOA) conducted for Experiment II ................. 68

Table 13. Total number of correct/total listener and speaker responses emitted and percentage of correct responses emitted by participants 1-6 during the initial and final probe sessions............................................................... 83
LIST OF FIGURES

Figure 1. Visual stimuli used during naming experiences and probe sessions 35

Figure 2. Auditory stimuli presented during naming experiences and subsequent probe sessions 36

Figure 3. Image of tactile stimulus presentation box used and tactile stimuli used in Experiment I 37

Figure 4. Image of olfactory stimuli used during naming experiences and probe sessions 38

Figure 5. Number of correct listener and speaker responses to visual, auditory, tactile, and olfactory stimuli emitted by Participant 1 during probe sessions 49

Figure 6. Number of correct listener and speaker responses to visual, auditory, tactile, and olfactory stimuli emitted by Participant 2 during probe sessions 50

Figure 7. Number of correct listener and speaker responses to visual, auditory, tactile, and olfactory stimuli emitted by Participant 3 during probe sessions 51

Figure 8. Number of correct listener and speaker responses to visual, auditory, tactile, and olfactory stimuli emitted by Participant 4 during probe sessions 52

Figure 9. Number of correct listener and speaker responses to visual, auditory, tactile, and olfactory stimuli emitted by Participant 5 during probe sessions 53

Figure 10. Number of correct listener and speaker responses to visual, auditory, tactile, and olfactory stimuli emitted by Participant 6 during probe sessions 54

Figure 11. Design sequence for Experiment II 67

Figure 12. Schematic drawing of participant’s view of the (a) visual; (b) auditory; (c) tactile; and (d) olfactory stimuli during the stimulus-stimulus pairings 70

Figure 13. Correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli by Dyad 1 (Participants 1 and 2) 73
Figure 14. Correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli by Dyad 2 ........................................... 74

Figure 15. Correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli by Dyad 3 (Participants 5 and 6) ............... 75

Figure 16. Total number of correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli per session for Participants 1 and 2 ........................................................................................................ 77

Figure 17. Total number of correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli per session for Participants 3 and 4 ........................................................................................................ 78

Figure 18. Total number of correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli per session for Participants 5 and 6 ........................................................................................................ 79

Figure 19. Total number of correct listener and speaker responses emitted across stimulus modalities during initial and final probe sessions for all participants .......................................................................................... 81

Figure 20. Differences between correct listener and speaker responses emitted across stimulus modalities during initial and final probe sessions for all participants .......................................................................................... 82
ACKNOWLEDGMENTS

I am truly grateful to all the people who have supported and guided me through the completion of this dissertation. I want to start by thanking my dissertation committee, Dr. Greer, Dr. Dudek, Dr. Wang, Dr. Peverly, and Dr. Matthews, for all of your time and helpful feedback. Each one of you provided such specific feedback which guided my drafts and edits provided a clear direction.

Dr. Greer, my sponsor and mentor, I am so grateful to have had your guidance throughout both the masters and doctoral programs. I could not imagine having been taught by anyone else and having the repertoires that I currently possess. I aspire to one day have your level of knowledge of pedagogy, applied behavior analysis, and verbal behavior and will continue to work towards that goal throughout my career. Thank you for conditioning those reinforcers.

Thank you to all of the friends I have made through CABAS®. To all of my TAs and mentees at Keller, I appreciate all of your hard work and dedication to the students in our classes. To my TAs and mentees from Class 9, I could not have completed my experiments without your help. Thank you for holding down the fort while I ran out of class to work on my study. Thank you, Bianca, Ellen, and Brenda, for allowing me to recruit students from your classes and pick them up whenever I needed them. I would like to thank the students and parents that made this all possible, without you I would not be here. Thank you all for your participation and flexibility.

Thank you, mom and dad, and the rest of my family for supporting me and always reminding me of the importance of education while growing up. I know that my monthly
disappearing acts (i.e. studying, paper writing, etc.) were not easy, but I know that you understood the level of focus I needed. I love you all.
DEDICATION

This dissertation is dedicated to my wife and son. Erika, thank you for continually reminding me of my potential and always supporting me in everything I do. Oliver, you taught me the importance of the use of all of the senses in the development of language which was the inspiration for this dissertation. I love you both.
CHAPTER 1
INTRODUCTION AND REVIEW OF THE LITERATURE

Introduction

The rate at which young neurotically children learn language is astonishing. Even more surprising is the discrepancy of language experiences received by children from low socio-economic status homes compared to high socio-economic homes (Hart & Risley, 1995). Before children are school-aged, the language experiences that they have at home from infancy to age 3 are crucial determinants of their future IQ scores and language abilities. By the end of their first year of life, children from professional families will have heard approximately 11 million words, while children from working class families would have heard 6.5 million words. That is almost half of the language experiences of the children from professional families! What's more disturbing is the 3.2 million words that a child from a family receiving welfare will be exposed to. These findings from Hart and Risley's (1995) longitudinal study of 42 families across a four-year period highlight the insurmountable dilemma that teachers must face when children enter preschool. How do we bridge the language gap for those children identified as having nearly a quarter of the language experiences of the children coming from rich language environments? Even still, how do we continue to expand on the language experiences of those children who enter preschool with such robust language histories?

Not only is the amount of language children are exposed to during their first few years of life essential, but recent research in the field of applied behavior analysis has identified verbal developmental cusps that, when present, may determine the extent to which language acquisition develops for young children (Greer & Ross, 2008; Greer &
Speckman, 2009; Longano & Greer, 2010; Longano & Greer, 2015). Horne and Lowe (1996) were the first to theorize this verbal developmental phenomenon, which they termed *naming*. A child is said to have naming when he or she can acquire untaught listener (e.g., pointing or selecting) and speaker (e.g. labeling) responses for stimuli after hearing someone say the name for a stimulus (e.g., car) while observing the stimulus, and later point to a *car* when asked and say *car* in the presence of a car. Thus, several researchers have attributed the language "explosion" children typically have around age 3 (Crystal, 2006; Hart & Risley, 1995) to be a result of these children having the naming capability, which allows them to learn language incidentally, that is, without direct instruction (Greer & Longano, 2010). These researchers have argued that a child must have the joint repertoires of listener and speaker to be truly verbal (Greer & Keohane, 2006; Greer & Speckman, 2009; Greer & Longano, 2010; Horne & Lowe, 1996; Skinner, 1957). When listener repertoires join with speaker repertoires, a child can learn vocabulary as a listener (e.g. responding to “point to the circle”), and without being directly taught, say “circle” when asked, “what is that?” in the presence of a circle. Fortunately, the initial independence of the listener and speaker repertoires has been empirically validated (Feliciano, 2006; Gilic, 2005; Greer & O’Sullivan 2007; Greer, Stolfi, et al., 2005; Greer, Stolfi, & Pistoljevic, 2007; Horne, Lowe, & Randle, 2004; Lee, 1981; Lowe, Horne, & Hughes, 2005; Sundberg & Sundberg, 1990; Tsiouri & Greer, 2007), which has provided much evidence as to the importance of the establishment of the naming capability in children and the effects on learning as a result of its acquisition.

Verbal behavior developmental theorists have proposed that the naming capability accrues as a result of specific learning histories involving rotated listener and speaker
experiences with visual stimuli (Fiorile & Greer, 2007; Gilic & Greer, 2011; Greer, Stolfi, Chavez-Brown, & Rivera-Valdes, 2005; Greer, Corwin, & Buttigieg, 2011; Greer, Stolfi, & Pistoljevic 2007). These and other researchers (Pistoljevic, 2008) have utilized visual stimuli in the identification and establishment of the naming capability. Still, results from other experiments have suggested that auditory speech stimuli become conditioned as reinforcers for orienting as well as the listener half of naming, following auditory stimulus discrimination training (Choi, 2012; Speckman-Collins, Park & Greer, 2007). The naming phenomenon has been investigated through experiments consisting of stimulus-stimulus pairings with spoken words and pictures (Longano & Greer, 2015), contrived and non-contrived auditory and visual stimuli (Lo, 2016), and actions (Cahill & Greer, 2014). Recent research (Greer & Du, 2016) has supported many of the initial theoretical formulations of naming purported by Horne and Lowe (1996) however, there has yet to be any research investigating the role of smell (i.e., olfaction) and touch (i.e., somatosensation) within the naming framework.

The current set of experiments investigate the role of other observing responses for stimuli across modalities, much like those proposed in the seminal example of the multimodal naming relation described by Horne and Lowe (1996). Horne and Lowe (1996) provided an example of a child who learns the name "dog", subsequently identifying a dog when a novel one is in sight, if the child hears its bark, touches its wet nose, or smells its fur as a function of the initial experience with seeing the dog and hearing its name. It has been reported that some children do benefit from specific conditioning histories across stimulus modalities, which result in the acquisition of names for both visual and auditory stimuli (Longano & Greer, 2015; Lo, 2016). When a child is
first introduced to a dog, she is not only able to see the dog, but hear and potentially feel and smell the dog, if proximity and temperament allow. It would be absurd to argue that a child is only observing the dog through a single modality (e.g. sight) each time a dog is experienced. Thus, a typical experience with a new dog includes stimuli that elicit observing responses for visual as well as auditory, somatosensory (i.e., tactile), and olfactory aspects that are present with the dog, which may affect a child’s subsequent response (e.g., approaching or running away from the dog) (Bahrick & Hollich, 2008). If children are to acquire language at such an explosive rate before school-age (Crystal, 2006; Hart & Risley, 1996), does the presence of naming for visual stimuli present an opportunity for other observing responses be conditioned though pairings of a visual stimulus with other modalities, leading to the acquisition of language through experiences involving other senses? Thus, the question remains, will the presence of naming for one stimulus modality, after being paired with other modalities, result in the emergence of naming for the other stimulus modalities as a function of a transfer of stimulus control? Research demonstrating the prerequisite conditioned reinforcement for visual and auditory stimuli suggests that this may be the case (Longano & Greer, 2015; Lo, 2016). It is important to determine the effects of language experiences involving multiple stimulus modalities available when a child observes a single stimulus, to guide the way that children are exposed to new words for things.

In the following literature review, I will present and summarize relevant research on the function of observing responses and stimulus control in the acquisition of language, describe research from fetal and infant research demonstrating early development of vision, audition, olfaction, and somatosensation; cognitive-
developmental theories of intermodal perception; and research from the applied behavior analytic fields which have varying theories on the roles of sensory modalities and learning as well as research on the verbal developmental capabilities necessary for learning language without direct instruction (i.e., incidentally). If these observing responses are developed at or before birth, do children who readily acquire the names of things they see also learn the names of things that they observe using their other senses? To bridge the "gap" identified by Hart and Risley (1995), the current investigation sought to determine whether specific language experiences can provide the necessary experiential histories for children to expand their language abilities when they experience a stimulus comprised of multiple modalities. Thus, Experiment I investigated whether there were differences in children’s demonstration of naming when the modality of the stimuli within the naming experiences were observed through other senses (i.e., auditory, tactile, and olfactory). The purpose of Experiment II was to investigate whether providing children with naming experiences involving simultaneous presentations of four different stimulus modalities with the same name would function to transfer stimulus control from one modality to the others.

**Observing Responses and Conditioned Reinforcement**

Responses that allow an organism to come into contact with stimuli in that organism’s environment by way of one or more sensory modalities (e.g. sight, sound, smell, touch, taste) have been identified within the literature as "observing responses" (Wyckoff, 1952). Observing responses have been described as being selected out by reinforcement contingencies (Wyckoff, 1969), thus several researchers have proposed
that observing responses are the best predictors of conditioned reinforcement (Dinsmoor, 1983; Keohane, Pereira-Delgado, & Greer, 2009).

Several published studies (Longano & Greer, 2015; Greer & Han, 2014; Greer, Pistoljevic, Cahill, & Du, 2011; Maffei, Singer-Dudek, & Keohane, 2014; Pereira-Delgado, Greer, Speckman, & Goswami, 2009; Keohane, Luke, & Greer, 2008; Longano & Greer, 2006; Du, Broto, & Greer, 2015; Greer, Dorow, & Hanser, 1973; Tsai, & Greer, 2006) and unpublished doctoral dissertations (Lo, 2016) have provided empirical support for the role of conditioned reinforcement functioning as a potential source of new observing responses to a variety of stimulus modalities. In these studies, the experimenters used a stimulus-stimulus pairing procedure (Longano & Greer, 2015) in which a previously neutral stimulus was paired with a conditioned or unconditioned stimulus and resulted in the transfer of reinforcing properties to the neutral stimulus as a result. This phenomenon has also been referred to as second-order conditioning (Catania, 2007). As a result of the pairing procedures used in these studies to condition new observing or orienting responses, there was an apparent shift in the stimulus control for observing behaviors relative to the history of reinforcement for a particular stimulus.

**Stimulus Control**

Morse and Skinner (1958) demonstrated that the contingency between a discriminative stimulus (e.g., odor) and reinforcement (e.g., food) is sufficient to give the discriminative stimulus (e.g., odor) some control over the responses (e.g. sniffing, orienting, approaching) that were subsequently conditioned with reinforcement (e.g., food). A stimulus has been defined by Michael (2004) as "an energy change that effects an organism through its receptor cells." Thus, a stimulus can be any change in an
organism's environment that can be observed through visual, auditory, olfactory, and somatosensory receptors, among others. This definition is essential in order to understand the role of conditioned reinforcement in the development and establishment of observing responses. It is a history of reinforcement for a stimulus in a particular stimulus modality (e.g., visual, auditory, tactile, olfactory), which establishes stimulus control of those stimuli for the observing or orienting responses. If a stimulus is observed in conjunction with an unconditioned or conditioned reinforcer, that stimulus, after a history of pairings with those reinforcers, will control the observing response, regardless of its particular topography (Greer & Du, 2016; Greer & Longano, 2015; Lo, 2016).

Stimulus control of observing responses following second-order conditioning procedures has been documented within infant and child research for looking at adult faces, 2-dimensional stimuli and 3-dimensional stimuli (i.e., visual stimuli; Du, Broto & Greer, 2015; Greer & Han, 2014; Maffei, Singer-Dudek, & Keohane, 2014), and selecting to listen to music and mother's voices (i.e., auditory stimuli; DeCasper & Spence, 1987; Greer, Dorow, Wachhaus & White, 1973; Greer, Pistoljevic, Cahill, & Du, 2011; Maffei, Singer-Dudek, & Keohane, 2014). Other researchers have demonstrated objective measures of olfactory stimulus control over observing responses in children between 32 and 68 hours old (Engen, Lipsitt & Kaye, 1963; Sullivan, Taborsky-Barba, Mendoza, Itano, Leon, Cotman, Payne & Lott, 1991). The development of the first observable instances (via ultrasound) of stimulus control for somatosensory stimuli (i.e., touch) has been observed in fetuses as early as 10 weeks of gestation (De Vries, Visser, & Prechtl, 1985) beginning with hand to head movements to both hands touching the head area by 36 weeks (De Vries, Wimmers, Ververs, Hopkins, Savelsbergh, & Van
These hand-to-face responses have been shown to develop systematically alongside the development of the somatosensory receptors around the mouth, cheeks, face and head (2001).

The evidence of the early observations of stimulus control over the senses of vision, audition, olfaction, and somatosensory receptors at such early stages of life have been purported as support for descriptions of language development (Chomsky, 1959) as innate behavior, which do not have supporting empirical evidence. This however is not the case when analyzing the research and describing reports from experimental observations of fetuses and infants from a behavior analytic perspective, which has identified certain observing responses missing in some children and subsequent effects on language development and acquisition when these cusps are induced (Greer & Du, 2015). Several researchers have argued that stimulus control can occur even before a child is born (DeCasper & Spence, 1987; Greer & Keohane, 2009; Greer & Speckman, 2009; Spence & DeCasper, 1987). In the following sections, the development of the perceptual senses will be discussed, followed by supporting evidence from the behavior analytic literature which establish the necessary observations of the effects of these senses as essential to the development of pre-verbal foundational cusps.

Unconditioned and Conditioned Sensory Observing Responses

In order to provide cohesive and clear definitions and descriptions, and in keeping with the verbal behavior of the science, the observing responses identified in other research fields will be discussed using relevant terms from the vocabulary of the science of behavior with translations derived from the sources offered for clarity when necessary.
The following subsections will review evidence from multiple research fields to provide a cohesive analysis of the development and subsequent establishment of observing responses and the conditioning processes that occur in early infancy. Extrapolations from the multiple fields of research will be made in order to combine both empirical evidence and theories that have been proposed, in an attempt to provide a cohesive and logical account of the development of multi-sensory observing responses and subsequent language acquisition. The information will be discussed in order in terms of the developmental sequence of the sense of touch (i.e., somatosensation), olfaction, audition, and vision, respectively (Gottlieb, 1971).

It is important to note that a distinction must be made when interpreting the results of experiments investigating sensation and perception, as these two constructs have been traditionally used interchangeably within the literature (Hepper, 2008). According to Hepper (2008), the term sensation refers to the "transduction of the physical signal by the sensory receptor and turning this signal into neural impulses" that are subsequently transmitted to the brain (p. 149). However, perception "is the process which adds meaning to these neural impulses as they interact with various centers and pathways in the brain." (p. 149). Here, these distinctions are not described in order to propose some physiological structure from which to infer functional laws of behavior, but to highlight the distinctions made within the literature which separate the internal mechanisms that occur in response to stimuli from the inferences proposed by authors investigating these responses. The current synthesis does not seek to explain behavior based on internal mechanisms or processes, however these processes are not discounted entirely within the field of behavior (Skinner, 1953; 1957). It seeks to make distinctions between definitions
found in the literature in order for an analysis of observable behaviors within studies of fetal and neonatal sensory development to be interpreted and proposed as potential sources of first instances of sensory observing responses. The aim of the following section is not to propose a divergent theory of physiological states regulating behavior; its function is to provide supporting evidence for the observed behaviors related to these internal states, or as McCorquodale (1970) has stated "it is behavioral data that illuminate [mediating structures], not the other way around" (p. 91). For this reason, each section will provide evidence of observed responses that occur in utero and during the first days of neonatal life, while also providing support from other literatures in order to conceptualize an argument for the establishment of observing responses occurring prior to post-natal experiences.

**Somatosensory (tactile) observing responses.** Responses to somatosensory stimuli have been identified as the first perceptual sense to develop in the unborn fetus as early as 8 weeks of gestation (Montagu, 1978). The current evidence identifying the development of somatosensory observing responses has been investigated in observational studies of fetuses (De Vries, Visser, & Prechtl, 1985; De Vries, Wimmers, Ververs, Hopkins, Savelsbergh, & Van Geijn, 2001; Kurjak, Azumendi, Varga, Kupesic, Solak, Varga, & Chervenak, 2003; Kurjak, Carrera, Medic, Azumendi, Andonotopo, & Stanojevic, 2005). One behavior that occurs in early gestation is hand to head contact (De Vries et al., 1985). These responses have been observed to occur at 10 weeks of gestation, using 4-D ultrasound. Other researchers have observed seven different kinds of movements/contacts that continue to occur throughout pregnancy; hand to head, hand to mouth, hand near mouth, hand to face, hand near face, hand to eye, and hand to ear
(Kurjak et al., 2005; Kurjak et al., 2003). At 36 weeks of gestation unimanual responses (i.e., single hand movements) shift to the use of both hands touching the head simultaneously (De Vries et al., 2001). These studies provide evidence of the gradual conditioning of touch over time (in utero) and the increases in touch responses observed across the studies further support this argument. According to Montagu (1978) fetuses respond to touch on the lips, cheeks, forehead, and palms of the hands in a progressive sequence. Thus, it can be argued that a conditioning process is occurring via hand to cheek contact, then progresses to other parts of the face, as the sensory receptors for touch continue to develop in utero.

Palaez, Gerwirtz, Field, Cigales, Malphurs, Clasky, and Sanchez (1996) investigated infants' preference for touch during face-to-face interactions with their mothers. Ten infants aged 1.5 to 3.5 months participated in this study. The experimenters used a within-subjects, alternating treatments (ABA, BAB) design to test the effects of contingent adult touch on eye contact (i.e., observing responses) to a mother's face. During the contingent touch phase, mothers paired touch with smiles, cooing, and touch with the child's eye contact in a conjugate reinforcement schedule (Maffei, et al, 2014). When the child stopped looking at the mother's face the smiling, cooing, and touch was removed and the child was turned away from the mother. During the non-touch condition, the mothers only delivered smiles and cooing contingent upon the child's eye contact. The results demonstrated that the infants emitted more smiles, vocalizations, and eye contact during the touch condition. These results demonstrate the reinforcing effects of touch for infants’ observing responses. Touch functioned to increase the children's
observing responses to faces, which has been demonstrated in more recent work by Maffei et al. (2014).

**Olfactory observing responses.** Chemosensory receptors in the nasal passages of fetuses are fully developed in the third trimester (28 weeks) of gestation allowing inhalation of amniotic fluid and the chemosensory stimuli ingested by the mother (Lecanuet & Schaal, 1996). Because of the inherent ethical limitations with studies involving fetal olfactory capacities, there is a lack of research demonstrating fetal olfaction in utero, however there is evidence that has demonstrated differential responding in premature infants that may be comparable to fetuses at six-months gestational age (Schaal, Orgeur, & Rognon, 1995). Other researchers have also observed differential responses to amniotic fluid, colostrum, and breast milk odors in infants under 96-hours of age (Marlier, Schaal, & Soussigan, 1998; Schaal, Marlier, & Soussigan, 1998; Porter & Winberg, 1999), as well as alcohol and foods ingested by mothers during pregnancy (Faas, Sponton, Moya, & Molina, 2000; Schaal, Marlier, & Soussigan, 2000).

Marlier, Schaal, and Soussigan (1998) observed that 3-day-old neonates demonstrated differential preferences for their own amniotic fluid over the amniotic fluid of another neonate, further supporting the notion of prenatal conditioning of olfactory stimuli. In a second experiment, Marlier et. al (1998) compared preferences of 134 2- and 4-day-old neonates using three paired-choice tests. With the 2-day-old neonates, the researchers compared head orientation in response to amniotic fluid versus colostrum; amniotic fluid versus a control (i.e., distilled water); and colostrum versus control (i.e., distilled water). On the fourth day, the researchers compared the same participant’s preferences for amniotic fluid versus breast milk; amniotic fluid versus control; and
breast milk versus control. The results demonstrated that (1) 2-day old infants demonstrated no differential preferences for amniotic fluid when presented with colostrum, suggesting that these stimuli have equivalent reinforcing values early on. They also found that (2) differential responses were observed when amniotic fluid and colostrum were presented with the control comparison stimulus, with head orientations in the direction of the amniotic fluid and colostrum when each was presented with a control stimulus (i.e., water). The results from Marlier et. al.'s (1998) study provide evidence to a potential conditioned reinforcement for observing responses to both amniotic fluid and colostrum when presented with a neutral stimulus. Results of the tests on 4-day-old infants demonstrated that (3) significantly more infants oriented towards breast milk versus amniotic fluid. It is important to note that all of the infants in this study were breastfeeding throughout the experiment. This finding further demonstrates the role of conditioning histories in the acquisition of conditioned reinforcement for new olfactory observing responses in the first days of life. That is, at 2-days-old the infants in this study did not demonstrate differential responding when exposed to amniotic fluid and colostrum, however, after 4 days of pairings of nutrients from their mother's breast milk (previously colostrum) and the olfactory stimuli within the breast milk, the infants demonstrated differential responding by orienting towards the newly conditioned olfactory stimuli from the breast milk when it was presented with amniotic fluid. The researchers also demonstrated that olfactory observing responses to amniotic fluid were not entirely placed into extinction, as evidenced by (4) the participants orienting towards amniotic fluid versus the control stimulus and (5) breast milk versus the control stimulus. The transfer of stimulus control from the initially equivalent reinforcing effects of
amniotic fluid and colostrum to observing responses increasing for breast milk
demonstrate an early example of conditioning histories that induce olfactory observing
responses.

If the results from Marlier et al. (1998) are interpreted from a behavior analytic
standpoint, it could be argued that a conditioning process was occurring throughout this
study, and the 2-day and 4-day tests could serve as probes of observing responses to
olfactory stimuli following a stimulus-stimulus pairing of the mothers' colostrum and
breast milk during feeding with the olfactory stimuli associated with those fluids. The
results of the amniotic fluid versus colostrum tests did not demonstrate differential
responding in the participants, potentially because the infants did not have sufficient
pairings of colostrum during the first 2-days of life. By the fourth day the experimenters
observed differential responses, with more observing responses for the breast milk versus
the amniotic fluid. This difference could be due to the pairings that occurred during
breast-feeding with the olfactory stimuli and the gradual extinction of observing
responses for amniotic fluid on the fourth day.

**Auditory observing responses.** Fetal responses to auditory stimuli have been
observed through observations of movements (Hepper, Scott, & Shahidullah, 1993) heart
rate (Lecanuet, Granier-Deferre, Jacquet, & Busnel, 1992), and functional magnetic
resonance imaging (fMRI) procedures (Moore, Vadeyar, Fulford, Tyler, Gribben, Baker,
James, & Gowland, 2001). Although current evidence has identified fetal responses to
auditory stimuli emerging at approximately 24-weeks gestational age (Hepper &
Shahidullah, 1994a), fetal sensitivity and range of frequencies of stimuli responded to
have been reported to continuously increase and expand as the fetus develops (Hepper & Shahidullah, 1994b).

Evidence of fetal and neonatal responses to auditory stimuli in humans suggests that early observing responses to these stimuli are detectible and demonstrate a conditioning history in utero that is observable within the first hours and days of postnatal life (Mampe, Friederici, Christophe, & Wermke, 2009). Several investigations of fetal and neonatal responses to auditory stimuli have demonstrated differential responding to the maternal voice that neonates experienced in utero to post-natal differential responses to these auditory stimuli (DeCasper & Fifer, 1980; DeCasper & Spence, 1986; Ockleford, Vince, Layton, & Reader, 1988; Querleu, Lefebvre, Titran, Renard, Morillion, & Crepin, 1984). Other investigations have demonstrated differential responses observed in fetuses in response to music (Kisilevsky, Hains, Jacquet, & Granier-Deferre, 2004), with a progressive change in responding to these stimuli over time. Preferences for native language (Moon, Cooper, & Fifer, 1993; Kuhl, Williams, Lacerda, Stevens & Lindblom, 1992), culture-specific music (Soley & Hannon, 2010), and evidence suggesting that neonates demonstrate discriminations of prosodic properties of words (Nazzi, Floccia, & Bertonici, 1993), taken together with recent evidence of culture-specific prosody of neonates’ cries (Mampe, et. al, 2009), reveal a potential conditioning history that occurs in utero for environment-specific auditory stimuli that can be objectively observed and measured following birth that shapes both observing responses to these stimuli as well as early vocal responses. Thus, early experiences with auditory stimuli are conditioned, potentially via nutrient pairings with these external
auditory stimuli (Greer & Du, 2015; Greer & Keohane, 2009; Greer & Speckman, 2009), and subsequently affect observing responses to auditory stimuli during infancy.

Greer, Pistoljevic, Cahill, and Du (2011) and Maffei, Singer-Dudek, and Keohane (2014) investigated the effects of conditioning listening to adult voices on subsequent observing responses, rate of acquisition of listener responses, and verbal operants emitted by children diagnosed with Autism. In both experiments the researchers conducted pre-experimental probes to determine if the participants observed recordings of adults’ voices telling stories. The dependent measures were the number of intervals that the participants depressed a button that would play the audio recording of the voice. The independent variable was a conjugate stimulus-stimulus pairing procedure in which the experimenter paired singing, physical contact, made novel facial movements, and sounds while the participants made eye contact. The results of these experiments demonstrated that the stimulus-stimulus pairing procedure functioned to condition listening to adult voices as a reinforcer. Other researchers have used similar measures and procedures to condition non-preferred music as a reinforcer following stimulus-stimulus pairings (Greer, Dorow, & Hanser, 1973; Greer, Dorow, Wachhaus, & White, 1973).

**Visual observing responses.** Research in infant preferences for visual stimuli has established that infants demonstrate preferences for faces (Bushnell, Sai, & Mullin, 1989; Walton, Bower, & Bower, 1992; Wilcox & Clayton, 1968), objects in motion (Volkmann, 1976), shapes and colors (Cohen, 1972; Spears, 1964), and lights (Cohen, 1969). The preferences for visually observing one stimulus over another does not necessarily indicate evidence of observing responses for visual stimuli, per se, however, there is evidence of potential conditioning processes that have conditioned observing
responses to mothers’ faces within the first few days of life for neonates (Field, Cohen, Garcia & Greenberg, 1984).

The identification of young children who were missing observing responses for 3-dimentional and 2-dimentional stimuli, and the subsequent establishment of conditioned reinforcement for observing responses to these stimuli, have demonstrated that, when missing, conditioning histories involving pairings of reinforcers with those observing responses resulted in the acquisition of conditioned reinforcement for looking at books and toys, print stimuli, and objects (Delgado Greer, Speckman, & Goswami, 2009; Du, Broto, & Greer, 2015; Greer, Becker, Saxe, & Mirabella, 1985; Greer & Han, 2014; Nuzzolo-Gomez, Leonard, Ortiz, Rivera, & Greer, 2002). Several other studies have demonstrated that these observing responses to adult faces occur following stimulus-stimulus pairings of reinforcers with observing responses to faces in children diagnosed with autism (Maffei, Singer-Dudek, & Keohane, 2014).

Research on the Identification and Establishment of Pre-verbal Foundational Cusps

The role of conditioning histories on the establishment of reinforcement from observing responses to stimuli has been one of the primary foci in the research field of verbal behavior developmental theorists (Greer & Du, 2015). Verbal behavior developmental theorists have experimentally identified the pre-verbal foundational cusps and capabilities necessary for children to acquire new behavior, reinforcers, and learn at faster rates (Greer & Du, 2015; Greer & Keohane, 2006; Greer & Speckman, 2009). A cusp allows a child to come into contact with aspects of his or her environment, which the child could not before the cusp was acquired (e.g., walking or speaking) (Rosales-Ruiz and Baer, 1996). When a child acquires a cusp that is also a capability, he or she can
learn listener and speaker functions from indirect contact with contingencies of reinforcement and punishment, thus, the child can learn in ways he or she could not before the capability was induced (Greer and Ross, 2008; Greer and Speckman, 2009). There are several pre-verbal foundational cusps that have been identified in the literature that are necessary for the acquisition of naming (Greer, et al., 2005; Greer & Ross, 2008; Greer & Speckman, 2009). These cusps are described as "pre-verbal" because they do not implicitly have a social function; however, when they are in a child's repertoire they facilitate the acquisition of faster rates of learning (Du, Broto & Greer, 2015; Du & Greer, 2014; Greer & Han, 2015; Greer, Pistoljevic, Cahill, & Du, 2011; Keohane, Luke, & Greer, 2008; Maffei, Singer-Dudek, & Keohane, 2014; Pereira-Delgado, Greer, Speckman, & Goswamy, 2008). The five pre-verbal foundational cusps that have been identified by verbal behavior developmental theorists are (1) conditioned reinforcement for observing 2-dimensional print stimuli (Greer & Han, 2015; Pereira-Delgado et al., 2008), (2) conditioned reinforcement for observing 3-dimentional objects (Du et al., 2015), (3) conditioned reinforcement for observing adult voices (Greer et al., 2011; Maffei et al., 2014) and (4) faces (Maffei et al., 2014), and (5) generalized imitation (i.e., see-do correspondence) (Du & Greer, 2014). Each of these pre-verbal foundational cusps is necessary for the acquisition of new language when inducing naming (Greer & Speckman, 2009). The newly conditioned reinforcers established when each cusp is acquired allow for new stimulus controls to select observing responses. When the names for those stimuli are presented in the presence of the stimulus and a child is emitting an observing response to the stimulus, this constitutes a naming experience (Longano & Greer, 2015).
**Behavior Analytic Theories of Equivalence and Language Acquisition**

**Stimulus equivalence.** The stimulus equivalence phenomena were reintroduced into the behavior analytic literature after a moratorium of over 30 years (as cited by Horne & Lowe, 1996) by Sidman (1971). Sidman’s (1994) reintroduction of stimulus equivalence proposed three distinct types of equivalence relations derived from logico-mathematical equivalence concepts (Hall & Chase, 1991). The three types of equivalence relations described by Sidman were, reflexivity, symmetry, and transitivity. An example of reflexive relations would be generalized matching of identical stimuli (e.g. picture of ball with an identical picture of a ball). An example of a symmetrical relation is if a child is directly taught to match a picture of a ball to the written text “ball” symmetry is demonstrated when the child, without direct instruction, matches the written text “ball” to the picture of the ball. Transitivity involves the child learning a third relation based on success in two previously trained relations. For example, after a child is taught to respond to a vocal stimulus “hat” by selecting the picture of the hat and the word hat in two separate training conditions, a child who demonstrated transitivity would match the picture of a hat to the text “hat” and the text “hat” to the picture without being directly taught. Although this theory seems quite simplistic (Sidman, 1994) its implications for language development are profound, as we shall later discuss.

The equivalence phenomena had begun to peak the interests of some researchers (Birch, 1962; Wepman, 1962) prior to the series of experiments conducted by Sidman in the early 70’s, which refined his initial conceptualization of the stimulus equivalence phenomena. Sidman’s (1971) seminal experiment with an adolescent boy with severe mental retardation was the first controlled experiment that demonstrated that two trained
relations could lead to the emergence of a new untrained relation. In this experiment, the participant was taught to match spoken words to pictures and match spoken words to printed words. After learning the two separate relations the participant was could match printed words to pictures without direct training, thus leading to the conclusion that derived stimulus relations, as the untaught emergence of equivalence responding has also been called, may be a prerequisite to reading comprehension (1971). Although the demonstration of equivalence by Sidman allowed for a resurgence of interest in equivalence research, it was not until his later experiments that more rigorous accounts of stimulus equivalence appeared (Sidman & Tailby, 1982; Sidman, 1986).

Sidman and Tailby (1982) defined stimulus equivalence as the hierarchical and bi-directional relationship between stimuli that allow for those stimuli to be related to one another. Sidman defined the three types of stimulus equivalence relations as reflexivity (A=A), symmetry (if A=B, then B=A), and transitivity (if A=B, B=C, then A=C). Typically studies that have investigated the phenomena have used matching-to-sample procedures to teach participants to match arbitrary stimuli and, after learning to match two sets of stimuli, demonstrating the acquisition of an untaught stimulus-stimulus relation.

The advent of the stimulus equivalence phenomena caught the attention of researchers studying the acquisition of human language, mainly in response to the similarities evident between performances of equivalence and the bi-directional characteristics of word-referent relations (Sidman & Tailby, 1982). After its inception, many researchers have investigated the associations between naming tasks such as relations between written words, spoken words, and pictures and objects, that occur
typically during early language training, using the framework from the stimulus equivalence literature (Dixon & Spradlin, 1976; Sidman, 1971; Spradlin & Dixon, 1976).

**Relational frame theory (RFT).** Relational frame theorists have identified and demonstrated components of stimulus equivalence that could not be explained by earlier equivalence theorists (Barnes-Holmes et al., 2000). Further, RFT was developed by Hayes as an attempt to explain complex human language and cognition based on behavior analytic principles. Specifically, RFT sought to provide a behavioral account of complex language and cognition, which Hayes argued was not addressed in Skinner’s (1957) description of verbal behavior. With its departure from the traditional Skinnerian approach to verbal behavior, verbal events were redefined as “derived arbitrary stimulus relations” (Barnes-Holmes, Barnes-Holmes & Murphy, 2004). According to RFT, behavior is considered to be verbal if both the speaker and the listener participate in the interaction, or frame. In addition, relational frames are contextually controlled (Hayes, Hayes, Sato, & Ono, 1994). Therefore, RFT provided a more narrowly focused approach to verbal behavior (Moore, 2008).

Rather than being a departure from the concepts formulated within stimulus equivalence, RFT adds to the conceptualization of equivalence and relational responding by accounting for arbitrarily applicable relations between and among stimuli. It expands on the concepts of symmetry and transitivity by 1) adding mutual entailment to the concept of symmetry and 2) by adding combinatorial entailment to the concept of transitivity. Mutual entailment is different in that when framing relations as comparisons rather than symmetrical to one another, for example if A is big then B is little, according to RFT the relations are mutually entailed. Using the same example, if A is bigger than B
and B is smaller than C, than the relation between A and C is of sameness and not opposite (big v little). In this example, the relation between A-B and B-C combine to entail the relation between A-C. Additionally, another component feature of RFT is the transformation of stimulus functions, which occurs when the function of a stimulus in a derived relation affects the functions of a different stimulus according to the derived relation between the two stimuli, without direct training (Hayes, 1991). It is this third component of RFT that is used to expand upon behavioral explanations of more complex behavior.

A distinguishing feature separating RFT from other theories based solely in the realm of behavior analysis is its appeal to the application of behavior analytic principles to explain unobservable human behaviors. According to Blackledge (2003) RFT includes “thoughts, emotions, physiological sensations, and overt behaviors” into its explanations of how relational frames develop. Causal relationships, relationships of coordination, and hierarchical relationships exist between these thoughts, emotions, sensations, and behaviors. An example of a causal relationship described by Blackledge (2003) would be the relations between the emotion of fear causing the behavior of running. An example of a relationship of coordination is demonstrated when two different stimuli elicit the same response (i.e., ‘snake’ and ‘danger’). An example of a hierarchical relationship would be when one stimulus in a certain context is part of a larger entity (i.e., ‘snake’ is related to ‘woods’). According to Blackledge (2003), any of these stimuli can potentially acquire the stimulus function of the other stimuli by virtue of the aforementioned relationships. Thus, being in the woods would elicit the same stimulus function (i.e., fear and subsequent running behavior) as being in the presence of a snake, because of the transfer
of the stimulus’ function (i.e., “snake” and “danger”) to the woods (i.e., “woods” now elicits the same behaviors brought about by the snake).

**Verbal behavior developmental theory (VBDT).** Verbal behavior developmental theorists have investigated and identified factors associated with the development of cusps and capabilities that children acquire that allow for faster rates of learning, expansion of the acquisition of new responses and stimulus controls, and the ability to learn in ways that they could not before the verbal capabilities were induced (Greer & Speckman, 2009). Verbal behavior developmental theory expands and adds to the research and theories described above, in an attempt to position the concepts illustrated by RFT and stimulus equivalence theorists, as well as naming theorists (Horne & Lowe, 1996), into a verbal behavior developmental framework centered around Skinner’s (1957) conceptualization of the progression of verbal behavior throughout human development. The identification of pre-foundational, listener, speaker, joined speaker-listener, reader and writer cusps and capabilities (Rosales-Ruiz & Baer, 1996) allows for a conceptually more consistent account of language acquisition and development. Borrowing from Skinner’s (1957) position on the initially independent listener and speaker repertoires, VBDT has demonstrated the identification and expansion of what Horne and Lowe (1996), Skinner (1957), and relational frame theorists (Blackledge, 2003) have proposed to be the fundamental component for one to be considered truly verbal—the joining of the initially independent listener and speaker repertoires (Greer, Chavez-Brown, et al, 2005; Greer & Longano, 2010).

According to VBDT, the listener and speaker repertoires develop independently of one another and later merge to establish such cusps as rotated listener and speaker
exchanges within an individual’s own skin (Lodhi & Greer, 1989), say-do correspondence (Paniagua & Baer, 1982; Rogers-Warren & Baer, 1976), and the naming capability (Greer & Longano, 2010).

Naming, when a child learns the names of stimuli upon observing a stimulus and hearing its name without being directly instructed or is taught in one topography (e.g. listener) and subsequently responds to the same stimulus as a speaker, is only one of the many verbal behavior cusps that have been identified by VBDT. It is the focus of the current investigation and requires further discussion regarding the stimulus modalities that have been previously investigated and identified in the literature and the apparent deficit of crucial scientific inquiry into other forms of naming.

**Stimulus Equivalence and Cross-modal Equivalence Relations**

Research based upon Sidman’s (1994) stimulus equivalence paradigm has suggested that participants who are taught two stimulus relations involving auditory, visual, tactile, and olfactory stimuli can learn untaught stimulus relations, indicating stimulus class formation (Annett & Leslie, 1995; Belanich & Fields, 1999; Fienup & Dixon, 2006; McAtamney & Annett, 2008; Tierney, De Largy & Bracken, 1995). Thus, the formation of equivalence classes across stimulus modalities has been tested thoroughly within the stimulus equivalence literature. However, typically these studies have used match-to-sample procedures to train and test for equivalence relations and have not addressed the role of the speaker within their analyses. This has also been the case within the field of perception, which has used similar match-to-sample methods when testing for cross-modal transfer (Ettlinger, 1977). This serves as a potential limitation in the extrapolation of these findings to language acquisition in that the match-to-sample
procedures that have been used account for only listener responses. The match-to-sample procedure does not involve production responses as a speaker, thus any conclusions drawn from these studies do not provide support for demonstration of equivalence relations as a speaker. No current research has investigated, specifically, the formation of equivalence classes for stimuli with participants responding as both listeners and speakers, which would demonstrate both criteria for full naming and thus the emergence of naming across stimulus modalities.

**Naming Research**

When a child can hear someone tact an object, feature, or event in the environment as the child and speaker observe the referent stimulus, and this experience results in the child selecting or pointing to the stimulus as a listener and emitting the tact for the stimulus in the presence of a listener or in response to a question regarding the label for the stimulus, the child is said to have the naming cusp and capability (Greer and Ross, 2008). A cusp allows a child to come into contact with aspects of the environment, which he or she could not before the cusp was acquired, leading to new opportunities for reinforcement (e.g. walking or speaking) (Rosales-Ruiz and Baer, 1996). Greer and Speckman (2009) made a distinction between cusps and cusps that are also capabilities. When a cusp is also a capability, a child can learn from indirect contact with contingencies of reinforcement and punishment (Greer and Ross, 2008; Greer and Speckman, 2009). Naming is both a verbal developmental cusp and capability because it allows children who have naming to acquire speaker and listener responses incidentally (Greer and Speckman, 2009). Children with the naming capability can emit listener (i.e., selection) responses and speaker (i.e., production) responses as a result of certain
encounters with their environment called “naming experiences” (Greer and Longano, 2010). These naming experiences result in multiple forms or stimulus control and multiple responses (i.e., listener and speaker responses), and can be experimentally controlled to induce naming in children who do not have naming. When children do not have naming the listener and speaker repertoires have not joined and mastery of listener and speaker responses in the presence of the same stimulus requires separate and direct instruction (Greer and Longano, 2010).

**Interventions to Induce Naming**

**Multiple exemplar instruction (MEI).** Multiple exemplar instruction is a procedure that has resulted in the induction of naming in multiple experiments (Fiorile and Greer, 2007; Gilic and Greer, 2011; Greer, Stolfi, Chavez-Brown, and Rivera-Valdez, 2005; Greer, Stolfi, and Pistoljevic, 2007; Helou-Care, 2008; Pistoljevic, 2008). MEI is also used in the development of abstract stimulus control (Becker, 1992), but for the purposes of this and the aforementioned studies using MEI, the procedure involves responding to multiple exemplars of stimuli across response topographies. In the studies that demonstrated the emergence of the naming capability using MEI, rather than varying the relevant and irrelevant features of the stimuli for single responses, multiple responses are taught for single stimuli and variants, resulting in joint stimulus control over listener and speaker responses (Greer and Longano, 2010; Greer and Ross, 2008). The MEI procedure involves the identification of multiple sets of stimuli for which the students cannot emit a listener or speaker response (e.g. point to or tact) such as novel animals, gems, or tree species (Greer, et. al, 2007). Other experiments have controlled for instructional histories by using contrived stimuli and tacts in their MEI interventions.
(Fiorile and Greer, 2007; Gilic and Greer, 2011; Greer, et. al, 2005; Helou-Care, 2008; Pistoljevic, 2008). The MEI procedures used in a majority of the studies investigating the naming capability involve teaching participants one or two sets of five stimuli while rotating the listener and speaker responses throughout the instruction. More specifically, students are taught to match stimuli while hearing the teacher tact each stimulus (e.g., looking at or giving the teacher the stimuli the teacher vocally labeled), intraverbally tact or emit a pure tact for the stimuli they matched (e.g., speaker responses), and emitting selection responses to the stimuli (e.g. pointing to the stimuli as a listener). During instructional trials a visual and auditory match-to-sample learn unit is followed by a listener response to a different stimulus in the set (e.g. pointing to the stimulus), this is followed by a speaker response (i.e., emitting an intraverbal tact in response to a question, “what is this?” or pure tact when the stimulus is presented without a vocal verbal antecedent. The rotation of stimuli during MEI is random to ensure the students are not echoing the previous response (e.g. after pointing to a dog, the student is presented with a picture of a dog and echoes the previous response “dog”). Thus, the rotation of stimuli and response types controls for echoic responses in the rotation of listener and speaker responses (Greer and Longano, 2010).

Greer, Stolfi, Chavez-Brown, and Rivera-Valdez (2005) investigated the effects of MEI on the transformation of stimulus function across listener and speaker responses for participants who did not have the naming capability following mastery of matching 2-dimensional stimuli while hearing the tacts for each stimulus they matched. Following MEI instruction in which the experimenters rotated match, point, pure tact, and impure tact responses for a different set of stimuli until mastery, the participants were probed for
the untaught responses for the first set of stimuli for which they did not initially demonstrate transformation of stimulus function. All of the participants acquired full naming for the first set of stimuli and a third set of novel stimuli. Fiorile and Greer (2007) induced naming in four children diagnosed with autism who did not demonstrate the emergence of naming after tact training alone. Following MEI across listener and speaker responses for a subset of stimuli the untaught response component of naming emerged and the participants demonstrated the acquisition of naming after learning tacts for novel sets of stimuli (2007). Gilic and Greer (2011) found that naming could be induced in typically developing children as young as two years old. The experimenters used MEI across speaker and listener responses to induce naming. The results showed that seven of the eight participants acquired naming after the MEI intervention. One of the main components within the MEI procedures used in these as well as other studies (Greer, Stolfi, Pistoljevic, 2007; Mosca, 2015) has demonstrated the emergence of the naming capability for visual stimuli. There is emerging evidence that the naming capability may extend beyond visual stimuli to include actions (Cahill & Greer, 2014) and sounds (Lo, 2016).

Greer, Stolfi, and Pistoljevic (2007) empirically evaluated the importance of the rotation of speaker and listener responses during MEI to induce naming. The experimenters compared single exemplar instruction (SEI), during which speaker and listener responses were taught separately, with multiple exemplar instruction (MEI) (i.e., speaker and listener responses were rotated) using a combined experimental-control group design with a nested multiple probe design across participants. The MEI group demonstrated the emergence of naming following multiple exemplar instruction while
naming was not induced in the control group that received SEI; however, naming emerged after MEI was introduced for the control group. The results demonstrated the importance of the rotation of the speaker and listener responses for the emergence of naming. In an unpublished doctoral dissertation, Pistoljevic (2008) replicated the results found in the study by Greer et. al, (2007) in one experiment comparing MEI to SEI and also demonstrated the emergence of naming.

It is necessary to note that the previous experimental investigations of multiple exemplar instruction involved direct consequences for the participants’ responses across response topographies. Also, the stimuli used in previous naming experiments did not use multiple exemplars of stimuli across stimulus modalities (e.g. visual, auditory, tactile, and olfactory). The current set of experiments expands upon the literature on the identification and establishment of naming to include auditory (Lo, 2016), tactile (i.e., somatosensory), and olfactory stimuli.

**Educational Significance and Rationale for the Present Experiments**

The evidence of the development of each of the perceptual senses of somatosensation, olfaction, audition, and vision suggest that early conditioning processes establish transfer of stimulus control from one modality to others because one or more stimuli are experienced simultaneously. More recent research has provided empirical support for the development of such a transfer as a function of stimulus-stimulus pairings of conditioned stimuli (e.g., visual) with unconditioned or neutral stimuli (e.g., auditory) (Longano & Greer, 2015; Lo, 2016). However, there is limited research that has investigated the argument that there may be multiple types of naming that are modality-specific (Greer & Du, 2015; Horne & Lowe, 1996; Longano & Greer, 2015).
It has been well documented that there appear to be specific conditioning histories that establish observing responses for different stimulus modalities (Cahill & Greer, 2014; De Vries, Visser, Prechtl, 1985; De Vries, Wimmers, Ververs, Hopkins, Savelsbergh, Van Geijn, 2001; DeCasper & Spence, 1987; Delgado Greer, Speckman, & Goswami, 2009; Du, Broto & Greer, 2015; Engen, Lipsitt & Kaye, 1963; Greer, Becker, Saxe, & Mirabella, 1985; Greer, Dorow, Wachhaus & White, 1973; Greer & Han, 2014; Greer & Longano, 2010; Greer, Pistoljevic, Cahill, & Du, 2011; Longano & Greer, 2015; Maffei, Singer-Dudek, & Keohane, 2014; Lo, 2016; Nuzzolo-Gomez, Leonard, Ortiz, Rivera, & Greer, 2002; Spence & DeCasper, 1987).

Most of the stimuli children experience in their environment are comprised of multiple modalities. A child with naming (for visual stimuli) can see a balloon and hear an adult say “That’s a balloon,” and subsequently point to the balloon when asked “find the balloon” and say “balloon” in the presence of a balloon. However, that same child may also hear the balloon pop, feel the balloon, and smell the rubber it is made from during that same experience. Researchers have not investigated the relations between the modalities which comprise a single stimulus and how exposure to those stimulus relations affect language acquisition. How then can a theory of incidental language acquisition not account for the different forms that may be observed during language experiences?

The following experiments provide a further analysis into role of conditioning histories in the acquisition of language across stimulus modalities. That is, if a child demonstrates naming when shown a picture and told its name, would that child also acquire listener and speaker responses when given an opportunity to hear, touch, and smell a stimulus while hearing its name? The purpose of Experiment I was to provide a
comparison of the differences between the acquisition of names for stimuli across visual, auditory, tactile, and olfactory modalities. Probes for untaught listener and speaker responses to visual, auditory, tactile, and olfactory stimuli were conducted following separate naming experiences with stimuli and distinct names assigned to each to determine if naming for modality-specific stimuli are separate cusps. To control for the names of stimuli in one modality affecting responses to other modalities, different names were assigned to each modality (i.e., the visual, auditory, tactile, and olfactory stimuli did not share the same names). Experiment II was a demonstration study which investigated whether simultaneous presentations of four stimulus modalities with one assigned name would result in the acquisition of naming for initially neutral stimulus modalities. It was hypothesized that the repeated stimulus-stimulus pairings would function to condition observing responses to the other stimulus modalities presented with the stimulus modality for which the participants initially demonstrated naming.
CHAPTER II
EXPERIMENT I

Method

Participants

Six preschool students, ranging from ages 4.2 to 5.2 years, participated in this study. The participants were selected from a publically funded, privately run preschool which serves children ranging from the ages of 18 months to five years near a major metropolitan area in the northeastern U.S. The school was a CABAS® (Comprehensive Application of Behavior Analysis to Schooling) model school, which is a cybernetic systems approach to instruction, in which the principles from the science of behavior analysis are implemented throughout all members of the child's school and home community. Four participants were neurotypically developing and two participants had a diagnosis of Autism. Criterion for inclusion in the current study was the demonstration of naming for visual stimuli, as identified by assessments conducted by the participants’ teachers, and the prerequisite self-management repertoires to attend to the experimental materials, follow vocal directions, and learn from instructional demonstrations. Naming probes conducted prior to the onset of the experiment may have yielded different results, therefore each of the participants in Experiment I received additional naming probes for visual stimuli. See Table 1 for a description of each participant.
Table 1

Participant Characteristics for Experiment 1

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender/Age</th>
<th>Classification</th>
<th>Level of Verbal Behavior</th>
<th>Listener Half of naming/Full naming&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (T)</td>
<td>M/5.2</td>
<td>Neurotypical</td>
<td>Listener/Speaker</td>
<td>Y/Y</td>
</tr>
<tr>
<td>2 (A)</td>
<td>F/4.6</td>
<td>Neurotypical</td>
<td>Listener/Speaker</td>
<td>Y/Y</td>
</tr>
<tr>
<td>3 (L)</td>
<td>F/4.2</td>
<td>Neurotypical</td>
<td>Listener/Speaker</td>
<td>Y/N</td>
</tr>
<tr>
<td>4 (S)</td>
<td>M/4.8</td>
<td>Autism</td>
<td>Listener/Speaker</td>
<td>Y/Y</td>
</tr>
<tr>
<td>5 (E)</td>
<td>F/4.2</td>
<td>Neurotypical</td>
<td>Listener/Speaker</td>
<td>Y/Y</td>
</tr>
<tr>
<td>6 (R)</td>
<td>M/4.3</td>
<td>Autism</td>
<td>Listener/Speaker</td>
<td>Y/Y</td>
</tr>
</tbody>
</table>

<sup>a</sup>The presence or absence of the listener and speaker half of naming demonstrated following the second naming probe session conducted with visual stimuli in Experiment 1.
Setting

All of the experimental sessions were conducted in a separate area of the school to prevent other participants from contacting the experimental stimuli out of the experimental context. The room contained a child-sized desk and chairs. A second observer was present for some of the sessions and a video camera recorded sessions in which a second observer was unavailable to collect inter-observer reliability throughout the experimental sessions. The video camera was positioned such that the participants' faces did not appear on the video, but their responses could be observed and heard in the recording.

Materials

The stimuli used in the current experiment included ten pairs of 50.8 mm by 50.8 mm tactile squares from a tactile matching game, a non-transparent canvas box with three 127 mm holes spaced approximately 127 mm apart cut into the bottom of the box and three sections made from canvas cloth attached to the inside of the box to create three equal sections, an assortment of essential oils in 29.57 ml ounce bottles with cotton balls inside, visual stimuli presented on index cards and a MacBook computer with Microsoft PowerPoint presentations for the auditory stimuli.

Each PowerPoint slide contained a single button (naming experience) or three buttons (listener probes) which, when clicked, would play a 3-s recording of a contrived sound (i.e., an unfamiliar word) (Lo, 2016). The experimenters used data collection sheets and black pens to record the participants' responses throughout the study. See Figures 1-4 for examples of the stimuli used in Experiment I.
Figure 1. An example of the visual stimuli used during naming experiences and subsequent listener and speaker probe sessions.
Figure 2. Example of auditory stimuli presented on a MacBook pro during naming experiences (Top) and subsequent probe sessions (Top: Speaker probes; Bottom: Listener probes).
Figure 3. Example of tactile stimulus presentation box used (Top) and tactile stimuli used in Experiment I (Bottom).
Figure 4. Example of olfactory stimuli used during naming experiences and subsequent probe sessions.
Design

The design of the current study was a repeated measures design across the senses. Each of the participants received separate naming experiences and probes for listener and speaker responses with (a) visual stimuli; (b) auditory stimuli; (c) tactile stimuli; and (c) olfactory stimuli. Probes were conducted across the four stimulus modalities across separate days for each participant for four sessions during which the experimenter tested for the presence of the naming capability across visual, auditory, tactile, and olfactory stimuli following naming experiences with stimuli in each modality. Thus, the first probe session for each participant was conducted using visual stimuli, followed by auditory stimuli on the following day, tactile stimuli on the third day, and olfactory on the fourth day. Once each participant completed the initial probes across the four modalities, the experimenter repeated the naming experiences and probes for all participants identically to the initial probes. Table 2 displays the stimulus sets and names and the participants who received each set used for Experiment I.
Table 2

*Stimulus modalities and contrived names assigned to each participant for Experiment 1*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Visual Stimuli</th>
<th>Tactile Stimuli</th>
<th>Auditory Stimuli</th>
<th>Olfactory Stimuli</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (T)</td>
<td>Jespen</td>
<td>Pallas</td>
<td>Hathor</td>
<td>Zia</td>
</tr>
<tr>
<td></td>
<td>Fleura</td>
<td>Odin</td>
<td>Vesta</td>
<td>Rupee</td>
</tr>
<tr>
<td></td>
<td>Duran</td>
<td>Chiro</td>
<td>Arsen</td>
<td>Ductor</td>
</tr>
<tr>
<td>2 (A)</td>
<td>Pallas</td>
<td>Hathor</td>
<td>Jespen</td>
<td>Juno</td>
</tr>
<tr>
<td></td>
<td>Odin</td>
<td>Vesta</td>
<td>Fleura</td>
<td>Terren</td>
</tr>
<tr>
<td></td>
<td>Chiro</td>
<td>Arsen</td>
<td>Duran</td>
<td>Zenner</td>
</tr>
<tr>
<td>3 (L)</td>
<td>Hathor</td>
<td>Jespen</td>
<td>Juno</td>
<td>Anka</td>
</tr>
<tr>
<td></td>
<td>Vesta</td>
<td>Fleura</td>
<td>Terren</td>
<td>Shekel</td>
</tr>
<tr>
<td></td>
<td>Arsen</td>
<td>Duran</td>
<td>Zener</td>
<td>Euro</td>
</tr>
<tr>
<td>4 (S)</td>
<td>Zia</td>
<td>Hathor</td>
<td>Anka</td>
<td>Tandan</td>
</tr>
<tr>
<td></td>
<td>Ductor</td>
<td>Vesta</td>
<td>Shekel</td>
<td>Yenty</td>
</tr>
<tr>
<td></td>
<td>Rupee</td>
<td>Arsen</td>
<td>Euro</td>
<td>Sirtip</td>
</tr>
<tr>
<td>5 (E)</td>
<td>Tandan</td>
<td>Juno</td>
<td>Pallas</td>
<td>Hathor</td>
</tr>
<tr>
<td></td>
<td>Yent</td>
<td>Terren</td>
<td>Odin</td>
<td>Vesta</td>
</tr>
<tr>
<td></td>
<td>Sirtip</td>
<td>Zener</td>
<td>Chiro</td>
<td>Arsen</td>
</tr>
<tr>
<td>6 (R)</td>
<td>Anka</td>
<td>Zia</td>
<td>Tandan</td>
<td>Jespen</td>
</tr>
<tr>
<td></td>
<td>Shekel</td>
<td>Ductor</td>
<td>Yenty</td>
<td>Fleura</td>
</tr>
<tr>
<td></td>
<td>Euro</td>
<td>Rupee</td>
<td>Sirtip</td>
<td>Duran</td>
</tr>
</tbody>
</table>

**Procedure**

*Naming experiences.* The naming experiences consisted of the experimenter modeling the target observing response and saying the name of the stimulus, and then giving the participant an opportunity to observe the stimulus in accordance with the target modality. For example, the experimenter held a scent bottle and modeled inhaling the scent. The experimenter then handed the bottle to the participant and provided an opportunity for the participant to observe the scent by smelling it and immediately provided the name for the scent (e.g., "Ductor"). None of the participants received
reinforcement or corrections for echoing the names, however they received reinforcement throughout the session for compliance such as sitting, attending, and refraining from touching the materials. Each naming experience consisted of five presentations of each of the three stimuli in a set, with one stimulus presented at a time, for a total of 15 opportunities for the participant to observe the stimuli. The participant was given a 5-min break, to maintain motivation, before receiving additional 15 naming experiences. Each participant received a total of 30 opportunities to observe the target stimuli in its respective modality (e.g., touching a stimulus while hearing its name) (10 opportunities to observe each of the three stimuli in a set) prior to the probes.

**Probes for naming.** Following a 2-hr break, the participants were shown an arrangement of the three stimuli in the set (e.g., three buttons displayed on the computer screen; the canvas box with three holes; three scent bottles) on the table and the experimenter probed for the listener half of naming. The listener probes were immediately followed by probes for the speaker half of naming in which each stimulus was presented one at a time and the participant was given 5-s to respond by saying the name of the stimulus. Each probe session consisted of 15 opportunities to respond as a listener and 15 opportunities to respond as speaker (5 opportunities per stimulus for each response topography). Each participant received two days of naming experiences and probes for each stimulus modality.

Naming experiences and probes were conducted across multiple days. For example, the participants received naming experiences and probes for visual stimuli on Day 1, naming experiences and probes for auditory stimuli on Day 2, naming experiences and probes for tactile stimuli on Day 3, and naming experiences and probes for olfactory
stimuli on Day 4. After the participants received probes for the four modalities, the experimenter repeated the naming experience and probe procedures for an additional session for all modalities in the same sequence.

**Probe Procedures**

**Listener responses to visual stimuli.** Listener responses during probes with visual stimuli involved the presentation of the one target visual stimulus and two non-target stimuli on the table. The experimenter provided the antecedent "Point to _____", to which the participant was required to respond by pointing to the corresponding picture within 5-s. Regardless of whether the participant responded correctly, incorrectly or did not respond within 5-s, the experimenter presented the next array of stimuli.

**Speaker responses to visual stimuli.** The speaker response probes were conducted immediately following the listener response probes. The experimenter presented each of the stimuli, one at a time, with the antecedent, "What is this?" If the participant responded correctly, incorrectly, or did not respond within 5-s, the experimenter presented the next picture in the set.

**Listener responses to tactile stimuli.** During listener response probes for tactile stimuli, the experimenter placed three tactile stimuli in a non-transparent box with three holes cut into the bottom measuring approximately 127 mm x 127 mm. The participant was given an opportunity to place his/her hand in each of the three holes and feel each stimulus. After the participant touched each stimulus in the box the experimenter asked the participant to "Point to ____". The participant was required to point to the corresponding hole with the named stimulus.
Speaker responses to tactile stimuli. During the probe sessions for speaker responses to tactile stimuli, the experimenter placed the target stimulus in the center hole of the box and gave the participant an opportunity to feel the stimulus and asked the participant "What is this?" to which the participant was required to respond with the name for the stimulus.

Listener responses to auditory stimuli. During probe sessions for listener responses to auditory stimuli the experimenter presented three buttons on a computer screen that, when clicked, played a 3-s audio sample. The experimenter pressed each of the buttons and delivered the antecedent, "Point to _____", to which the participant was required to respond by touching the target button on the screen.

Speaker responses to auditory stimuli. Following the listener response probe session for auditory stimuli, the experimenter conducted speaker response probes for the auditory stimuli. During the speaker response probes the experimenter presented one button on a computer screen and clicked the button to play the auditory stimulus while asking the participant "What is this?" The participant was required to say the name of the stimulus within 5-s after hearing the audio sample.

Listener responses to olfactory stimuli. During probe sessions for listener responses to olfactory stimuli the experimenter presented the participant with three small dropper bottles with scented cotton balls inside. The experimenter placed the three bottles in front of the participant and gave the participant an opportunity to smell each of the bottles. The experimenter then said, "Point to ___". The student was given 5-s to respond after smelling the third bottle by pointing to the target stimulus.
Speaker responses to olfactory stimuli. Immediately following the listener response probes, the experimenter conducted intraverbal tact probes for the speaker responses to the olfactory stimuli. During the speaker probe sessions, the experimenter gave one bottle to the participant to smell and asked, "What is this?" The participant was given 5-s to respond with the name of the olfactory stimulus.

Data Collection

Data were collected for correct and incorrect responses emitted during all probe sessions. The experimenter also recorded all echoic responses emitted during the naming experiences. During the probes for listener responses, correct responses were recorded as a plus (+) if the participant selected the target stimulus after the experimenter's vocal direction, "Point to ____". If the participant emitted an incorrect response a minus (-) was recorded. Incorrect responses were recorded if the participant selected a non-target stimulus during listener probe, named a non-target stimulus during speaker probes, or did not respond within 5-s of the experimenter's antecedent. Additionally, if the participant emitted a response and subsequently emitted a response that demonstrated that the initial response was incorrect after he or she observed the selected a stimulus during listener probes, for example, if the participant pointed to the center button when asked to point to "ductor" and upon hearing the selected button, the participant said "that's not ductor" the experimenter allowed the participant to observe all of the stimuli a second time and represented the antecedent. This was done whether the participant initially selected the correct or incorrect stimulus. The experimenter counted the second response as the final response for the participant.
**Interobserver Agreement**

Interobserver agreement (IOA) was collected during all probe sessions using trial-by-trial IOA (Cooper, Heron & Heward, 2007). Trial-by-trial IOA consists of both observers calculating the total number of agreements of correct responses recorded per trial and dividing by the total number of trials and multiplying by 100. The second observer conducted IOA in-vivo, during the probe sessions or at a later date via video recordings of the probe sessions. Interobserver agreement was conducted for 50% of the listener and speaker probe sessions across all participants for all four-stimulus modalities with 100% agreement. See Table 3 for a summary of the IOA for Experiment I.

Table 3

*Interobserver agreement (IOA) conducted for Experiment I*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Percentage of Probe Sessions with IOA</th>
<th>Percentage of Agreement between Observers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25%</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>25%</td>
<td>100%</td>
</tr>
<tr>
<td>3</td>
<td>25%</td>
<td>100%</td>
</tr>
<tr>
<td>4</td>
<td>75%</td>
<td>100%</td>
</tr>
<tr>
<td>5</td>
<td>75%</td>
<td>100%</td>
</tr>
<tr>
<td>6</td>
<td>75%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Results**

**Initial Naming Experience and Probes**

The participants' responses to untaught listener and speaker responses across the four stimulus modalities are presented in Table 4. The experimenter set the criterion for
the presence of naming at 80% (12 out of 15 correct responses) (Greer, et al., 2005). The results of the initial probes for visual stimuli showed that two participants demonstrated the listener half of naming and two participants demonstrated full naming. Participants 2 and 5 did not demonstrate the listener or speaker half of naming, however, Participant 2's listener responses were near criterion (i.e., 11/15 or 73.33%) and Participant 5 emitted near criterion level speaker responses (i.e., 11/15 or 73.33%). Following the initial naming experience with auditory stimuli, Participant 6 demonstrated only the Speaker half of naming. During probes with tactile stimuli, Participant 2 demonstrated the listener half of naming and Participant 6 demonstrated the speaker half of naming. Following the olfactory naming experiences, only Participant 4 demonstrated the listener half of naming for olfactory stimuli. Figures 5 through 10 display the listener and speaker probe results for each of the participants across visual, auditory, tactile, and olfactory stimulus modalities.
Table 4

Number of correct/total listener and speaker responses emitted by participants across four stimulus modalities following initial naming experience.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Listener Responses to Visual Stimuli</th>
<th>Speaker Responses to Visual Stimuli</th>
<th>Listener Responses to Auditory Stimuli</th>
<th>Speaker Responses to Auditory Stimuli</th>
<th>Listener Responses to Tactile Stimuli</th>
<th>Speaker Responses to Tactile Stimuli</th>
<th>Listener Responses to Olfactory Stimuli</th>
<th>Speaker Responses to Olfactory Stimuli</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 (A)</td>
<td>11/15</td>
<td>10/15</td>
<td>3/15</td>
<td>1/15</td>
<td>13/15</td>
<td>5/15</td>
<td>6/15</td>
<td>0/15</td>
</tr>
<tr>
<td>3 (L)</td>
<td>12/15</td>
<td>0/15</td>
<td>3/15</td>
<td>0/15</td>
<td>5/15</td>
<td>0/15</td>
<td>5/15</td>
<td>0/15</td>
</tr>
<tr>
<td>4 (S)</td>
<td>15/15</td>
<td>15/15</td>
<td>5/15</td>
<td>11/15</td>
<td>7/15</td>
<td>9/15</td>
<td>13/15</td>
<td>7/15</td>
</tr>
<tr>
<td>5 (E)</td>
<td>7/15</td>
<td>11/15</td>
<td>10/15</td>
<td>8/15</td>
<td>1/15</td>
<td>5/15</td>
<td>8/15</td>
<td>5/15</td>
</tr>
<tr>
<td>6 (R)</td>
<td>14/15</td>
<td>15/15</td>
<td>10/15</td>
<td>14/15</td>
<td>6/15</td>
<td>15/15</td>
<td>6/15</td>
<td>5/15</td>
</tr>
</tbody>
</table>

Secondary Naming Experiences and Probes.

Table 5 presents the participants' listener and speaker responses emitted during probes following the second naming experience with the same stimuli. Following the second naming experience, Participants 1, 2, and 5 demonstrated full naming for visual stimuli. Participants 1 and 3 demonstrated the listener half of naming for auditory stimuli. For the tactile stimuli probes Participants 1 and 2 demonstrated full naming.
Table 5

Participants' number of correct/total listener and speaker responses emitted during both probe sessions across four stimulus modalities.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Probe</th>
<th>Listener Responses to Visual Stimuli</th>
<th>Speaker Responses to Visual Stimuli</th>
<th>Listener Responses to Auditory Stimuli</th>
<th>Speaker Responses to Auditory Stimuli</th>
<th>Listener Responses to Tactile Stimuli</th>
<th>Speaker Responses to Tactile Stimuli</th>
<th>Listener Responses to Olfactory Stimuli</th>
<th>Speaker Responses to Olfactory Stimuli</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (T)</td>
<td>1</td>
<td>14/15</td>
<td>10/15</td>
<td>3/15</td>
<td>1/15</td>
<td>11/15</td>
<td>2/15</td>
<td>9/15</td>
<td>4/15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>14/15</td>
<td>15/15</td>
<td>14/15</td>
<td>5/15</td>
<td>15/15</td>
<td>14/15</td>
<td>12/15</td>
<td>9/15</td>
</tr>
<tr>
<td>2 (A)</td>
<td>1</td>
<td>11/15</td>
<td>10/15</td>
<td>3/15</td>
<td>1/15</td>
<td>13/15</td>
<td>5/15</td>
<td>6/15</td>
<td>0/15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>13/15</td>
<td>15/15</td>
<td>7/15</td>
<td>5/15</td>
<td>15/15</td>
<td>15/15</td>
<td>2/15</td>
<td>0/15</td>
</tr>
<tr>
<td>3 (L)</td>
<td>1</td>
<td>12/15</td>
<td>0/15</td>
<td>3/15</td>
<td>0/15</td>
<td>5/15</td>
<td>0/15</td>
<td>5/15</td>
<td>0/15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10/15</td>
<td>7/15</td>
<td>12/15</td>
<td>0/15</td>
<td>6/15</td>
<td>0/15</td>
<td>0/15</td>
<td>0/15</td>
</tr>
<tr>
<td>4 (S)</td>
<td>1</td>
<td>15/15</td>
<td>*</td>
<td>15/15</td>
<td>*</td>
<td>5/15</td>
<td>11/15</td>
<td>7/15</td>
<td>9/15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>*</td>
<td>*</td>
<td>7/15</td>
<td>11/15</td>
<td>2/15</td>
<td>11/15</td>
<td>12/15</td>
<td>14/15</td>
</tr>
<tr>
<td>5 (E)</td>
<td>1</td>
<td>7/15</td>
<td>11/15</td>
<td>10/15</td>
<td>8/15</td>
<td>1/15</td>
<td>5/15</td>
<td>8/15</td>
<td>5/15</td>
</tr>
<tr>
<td>6 (R)</td>
<td>1</td>
<td>14/15</td>
<td>15/15</td>
<td>10/15</td>
<td>14/15</td>
<td>6/15</td>
<td>15/15</td>
<td>6/15</td>
<td>5/15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>14/15</td>
<td>15/15</td>
<td>5/15</td>
<td>12/15</td>
<td>2/15</td>
<td>15/15</td>
<td>7/15</td>
<td>12/15</td>
</tr>
</tbody>
</table>

Note: The same set of stimuli were used in both probe sessions.
Figure 5. Number of correct listener and speaker responses to visual (top left), auditory (top right), tactile (bottom left) and olfactory (bottom right) stimuli emitted by Participant 1 during initial and subsequent probe sessions. NOTE: Horizontal line denotes criterion.
Figure 6. Number of correct listener and speaker responses to visual (top left), auditory (top right), tactile (bottom left) and olfactory (bottom right) stimuli emitted by Participant 2 during initial and subsequent probe sessions. NOTE: Horizontal line denotes criterion.
Figure 7. Number of correct listener and speaker responses to visual (top left), auditory (top right), tactile (bottom left) and olfactory (bottom right) stimuli emitted by Participant 3 during initial and subsequent probe sessions. NOTE: Horizontal line denotes criterion.
Figure 8. Number of correct listener and speaker responses to visual (top left), auditory (top right), tactile (bottom left) and olfactory (bottom right) stimuli emitted by Participant 4 during initial and subsequent probe sessions. NOTE: Horizontal line denotes criterion.
Figure 9. Number of correct listener and speaker responses to visual (top left), auditory (top right), tactile (bottom left) and olfactory (bottom right) stimuli emitted by Participant 5 during initial and subsequent probe sessions. NOTE: Horizontal line denotes criterion.
Figure 10. Number of correct listener and speaker responses to visual (top left), auditory (top right), tactile (bottom left) and olfactory (bottom right) stimuli emitted by Participant 6 during initial and subsequent probe sessions. NOTE: Horizontal line denotes criterion.
Discussion and Rationale for Experiment II

Following two naming experiences all six of the participants in Experiment I demonstrated the listener half of naming for at least one of the four stimulus modalities being investigated. Participant 5 demonstrated full naming for visual stimuli following the second naming experience. As was the case in previous experiments (Lo, 2016) following repeated probe sessions, naming accrued for participants who did not initially demonstrate naming for particular stimulus modalities. However, there are potential limitations to consider, due to the second session of naming experiences that the participants received before the second probe sessions. The experimenter argues that the rotation of stimulus modality and contrived names across modalities would have had an effect on the secondary naming probes due to observations of participants emitting previously experienced contrived names for the incorrect stimuli (e.g. tacting an olfactory stimulus as "Hathor" when "hathor" was a contrived name assigned to a tactile stimulus that was presented the prior day). The experimenter observed tacts for stimuli from other modalities being emitted during probe sessions. Thus, it is not clear whether increases in correct responses were a function of repeated exposure to the probe conditions. Previous research studies investigating naming for visual stimuli have provided 40 or more opportunities for participants to hear the names of the target stimuli after completing two sessions of match-to-sample instruction (Glic, 2005; Greer et al., 2005; Longano, 2008; Pistoljevic, 2008).

It is important to note that the results of the probes for Participant 6 appear to be inconsistent with the conclusions of previous naming studies which have demonstrated that the listener half of naming is a prerequisite to the acquisition of the speaker half
Participant 6 did not have the self-management repertoires necessary to attend to the stimulus presentations during the probes for auditory, tactile, and olfactory stimuli. The nature of the procedures for the probes for listener responses required the participant to attend to each stimulus presentation before responding, which took a considerable amount of time since Participant 6 repeatedly left the table, and attempted to speak to the experimenter during the probe sessions. He was considered to have naming because of the high number of correct responses he emitted during the speaker probes. Participant 6 also labeled the stimuli during the listener probes as the experimenter presented them (e.g., while the experimenter pressed each auditory button or gave the participant a bottle to smell, he would call out its name).

Experiment II was a demonstration study which investigated the effects of repeated stimulus-stimulus pairings of stimulus names with simultaneous presentations of four different modalities for each stimulus name. I used repeated stimulus-stimulus pairings of modality sets, consisting of visual, auditory, tactile, and olfactory stimuli, with the same names assigned to each modality set. The stimulus-stimulus pairings simulated experiences in which the participants would typically be exposed to the name of a stimulus in a particular modality (e.g., hearing a balloon pop and someone saying “the balloon popped, and smelling and feeling the rubber when a child holds a balloon and hears its name) in the presence of other modalities. Experiment II tested whether the stimulus-stimulus pairings would function as a conditioning process leading to the acquisition of untaught listener and speaker responses to initially neutral stimuli.
CHAPTER III
EXPERIMENT II

Participants

Six preschool students aged 4.2 to 5.2 years-old participated in the study. Participants 1 through 5 from Experiment I were selected to participate because they demonstrated full naming for some of the stimulus modalities but did not demonstrate full naming across all four stimulus modalities under investigation. Participant 6 was selected to participate in Experiment II because he demonstrated full naming for visual stimuli when assessed by his classroom teacher. See Table 6 for a description of each participant.

Table 6

Descriptions of participants in Experiment II.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender/Age</th>
<th>Classification</th>
<th>Level of Verbal Behavior</th>
<th>Listener Half/Speaker Half of naming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Visual Stimuli</td>
</tr>
<tr>
<td>1</td>
<td>F/4.6</td>
<td>Neurotypical</td>
<td>Listener/Speaker</td>
<td>Y/Y</td>
</tr>
<tr>
<td>2</td>
<td>F/4.2</td>
<td>Neurotypical</td>
<td>Listener/Speaker</td>
<td>Y/N</td>
</tr>
<tr>
<td>3</td>
<td>M/4.8</td>
<td>Autism</td>
<td>Listener/Speaker</td>
<td>Y/Y</td>
</tr>
<tr>
<td>4</td>
<td>F/4.2</td>
<td>Neurotypical</td>
<td>Listener/Speaker</td>
<td>Y/Y</td>
</tr>
<tr>
<td>5</td>
<td>M/4.3</td>
<td>Autism</td>
<td>Listener/Speaker</td>
<td>Y/Y</td>
</tr>
<tr>
<td>6</td>
<td>M/5.2</td>
<td>Neurotypical</td>
<td>Listener/Speaker</td>
<td>Y/Y</td>
</tr>
</tbody>
</table>

Setting
The setting for Experiment II was identical to Experiment I.

Materials

The materials used in Experiment II were (1) contrived symbols for the visual stimuli taken from a Google Image search for “alchemy symbols” (Table 7), (2) contrived sound effects derived from a recent doctoral dissertation (Lo, 2016), (3) tactile squares from the tactile matching game Teachable Touchables, in addition to index cards with various textures glued onto each card (e.g. rice, beans, feathers, toothpicks, aluminum foil) (Table 8), and (4) assorted essential oils (Table 9). The visual stimuli were presented on 76.2 mm by 127 mm index cards, the auditory stimuli were presented on a MacBook computer using PowerPoint, the tactile stimuli were presented in a canvas box, placed on its side, with holes cut into the bottom and three sections equally dividing the box into thirds, and 38.1 mm dropper bottles with cotton balls and 5-6 drops of essential oils on the cotton balls inside each bottle.
Table 7

Contrived alchemy symbols used during stimulus-stimulus pairings and probe sessions

<table>
<thead>
<tr>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Symbol 1" /></td>
<td><img src="image2" alt="Symbol 2" /></td>
<td><img src="image3" alt="Symbol 3" /></td>
<td><img src="image4" alt="Symbol 4" /></td>
</tr>
<tr>
<td>5.</td>
<td>6.</td>
<td>7.</td>
<td>8.</td>
</tr>
<tr>
<td><img src="image5" alt="Symbol 5" /></td>
<td><img src="image6" alt="Symbol 6" /></td>
<td><img src="image7" alt="Symbol 7" /></td>
<td><img src="image8" alt="Symbol 8" /></td>
</tr>
<tr>
<td>9.</td>
<td>10.</td>
<td>11.</td>
<td>12.</td>
</tr>
<tr>
<td><img src="image9" alt="Symbol 9" /></td>
<td><img src="image10" alt="Symbol 10" /></td>
<td><img src="image11" alt="Symbol 11" /></td>
<td><img src="image12" alt="Symbol 12" /></td>
</tr>
<tr>
<td>13.</td>
<td>14.</td>
<td>15.</td>
<td>16.</td>
</tr>
<tr>
<td><img src="image13" alt="Symbol 13" /></td>
<td><img src="image14" alt="Symbol 14" /></td>
<td><img src="image15" alt="Symbol 15" /></td>
<td><img src="image16" alt="Symbol 16" /></td>
</tr>
<tr>
<td>17.</td>
<td>18.</td>
<td>19.</td>
<td>20.</td>
</tr>
<tr>
<td><img src="image17" alt="Symbol 17" /></td>
<td><img src="image18" alt="Symbol 18" /></td>
<td><img src="image19" alt="Symbol 19" /></td>
<td><img src="image20" alt="Symbol 20" /></td>
</tr>
</tbody>
</table>
Table 8

Tactile stimuli used during stimulus-stimulus pairings and probe sessions.

<table>
<thead>
<tr>
<th>Number</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scratchy textile</td>
</tr>
<tr>
<td>2</td>
<td>Smooth textile</td>
</tr>
<tr>
<td>3</td>
<td>Bumpy textile</td>
</tr>
<tr>
<td>4</td>
<td>Silk textile</td>
</tr>
<tr>
<td>5</td>
<td>Velcro textile</td>
</tr>
<tr>
<td>6</td>
<td>Fluffy textile</td>
</tr>
<tr>
<td>7</td>
<td>Corduroy textile</td>
</tr>
<tr>
<td>8</td>
<td>Leather textile</td>
</tr>
<tr>
<td>9</td>
<td>Wool textile</td>
</tr>
<tr>
<td>10</td>
<td>Rice texture</td>
</tr>
<tr>
<td>11</td>
<td>Toothpick texture</td>
</tr>
<tr>
<td>12</td>
<td>Bean texture</td>
</tr>
<tr>
<td>13</td>
<td>Ridged texture</td>
</tr>
<tr>
<td>14</td>
<td>Spikey texture</td>
</tr>
<tr>
<td>15</td>
<td>Texture with holes cut out</td>
</tr>
<tr>
<td>16</td>
<td>Foam texture</td>
</tr>
<tr>
<td>17</td>
<td>Canvas texture</td>
</tr>
<tr>
<td>18</td>
<td>Rubber texture</td>
</tr>
<tr>
<td>19</td>
<td>Wood texture</td>
</tr>
<tr>
<td>20</td>
<td>Dried clay texture</td>
</tr>
</tbody>
</table>
Table 9

*Essential Oils used during stimulus-stimulus pairings and probe sessions*

<table>
<thead>
<tr>
<th>Number</th>
<th>Essential Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Frankincense</td>
</tr>
<tr>
<td>2</td>
<td>Lavender</td>
</tr>
<tr>
<td>3</td>
<td>Sweet Orange</td>
</tr>
<tr>
<td>4</td>
<td>Clove</td>
</tr>
<tr>
<td>5</td>
<td>Eucalyptus</td>
</tr>
<tr>
<td>6</td>
<td>Rosemary</td>
</tr>
<tr>
<td>7</td>
<td>Bergamot</td>
</tr>
<tr>
<td>8</td>
<td>Dill weed</td>
</tr>
<tr>
<td>9</td>
<td>Key Lime</td>
</tr>
<tr>
<td>10</td>
<td>Tea Tree</td>
</tr>
<tr>
<td>11</td>
<td>Nutmeg</td>
</tr>
<tr>
<td>12</td>
<td>Anise Star</td>
</tr>
<tr>
<td>13</td>
<td>Parsley</td>
</tr>
<tr>
<td>14</td>
<td>Vanilla</td>
</tr>
<tr>
<td>15</td>
<td>Basil</td>
</tr>
<tr>
<td>16</td>
<td>Pine</td>
</tr>
<tr>
<td>17</td>
<td>Wintergreen</td>
</tr>
<tr>
<td>18</td>
<td>Coffee</td>
</tr>
<tr>
<td>19</td>
<td>Fennel</td>
</tr>
<tr>
<td>20</td>
<td>Cumin</td>
</tr>
</tbody>
</table>
Table 10

**Contrived Two-syllable, Phonemically Transparent Words used during stimulus-stimulus pairings and probe sessions**

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bremo</td>
</tr>
<tr>
<td>2</td>
<td>Tanger</td>
</tr>
<tr>
<td>3</td>
<td>Flory</td>
</tr>
<tr>
<td>4</td>
<td>Dunger</td>
</tr>
<tr>
<td>5</td>
<td>Remoke</td>
</tr>
<tr>
<td>6</td>
<td>Feger</td>
</tr>
<tr>
<td>7</td>
<td>Yazy</td>
</tr>
<tr>
<td>8</td>
<td>Repum</td>
</tr>
<tr>
<td>9</td>
<td>Bissy</td>
</tr>
<tr>
<td>10</td>
<td>Tufest</td>
</tr>
<tr>
<td>11</td>
<td>Epack</td>
</tr>
<tr>
<td>12</td>
<td>Cosper</td>
</tr>
<tr>
<td>13</td>
<td>Tammy</td>
</tr>
<tr>
<td>14</td>
<td>Bunfor</td>
</tr>
<tr>
<td>15</td>
<td>Haltok</td>
</tr>
<tr>
<td>16</td>
<td>Nenyo</td>
</tr>
<tr>
<td>17</td>
<td>Ambot</td>
</tr>
<tr>
<td>18</td>
<td>Kesler</td>
</tr>
<tr>
<td>19</td>
<td>Polig</td>
</tr>
<tr>
<td>20</td>
<td>Untike</td>
</tr>
</tbody>
</table>

**Stimulus name assignment**

The experimenter selected contrived, two-syllable, phonemically transparent words from a recent doctoral dissertation (Lo, 2016) and created additional words to control for phonemically similar words on the list (Table 10). The words selected for the experiment were considered contrived because they were unfamiliar to the participants and would not have a pre-existing instructional history with the names. Each contrived word was assigned a number from 1-20. The experimenter then created a numbered list of 20 visual, auditory, tactile, and olfactory stimuli. A contrived assignment sheet was used to assign contrived names and stimuli across the four modalities to each participant.
A non-repeating random number generator was used to assign three contrived names to each participant. The first three numbers generated indicated the three contrived names that were to be assigned to the stimuli for Participant 1. After the experimenter selected the three contrived names for a participant, the experimenter repeated the number selection procedures to select three visual, auditory, tactile, and olfactory stimuli and assigned the contrived names to each of the stimuli in the same order that they were selected. For example, if the number generator selected contrived names 7, 8, and 11 (i.e. Yazy, Repum, and Epack, respectively), and then generated the numbers 15, 3, and 6; visual stimulus 15 would be assigned the contrived name “yazy”, visual stimulus 3 would be assigned the name “repum” and visual stimulus 6 would be assigned the name “epack”. This procedure was used to select and assign contrived names with each of the stimulus modalities used for each participant. This process was used for the selection of all of the stimuli used for each participant, however, the experimenter removed contrived names from the available list when a name was assigned to a participant. Therefore, no two participants had the same contrived names, but could potentially have the same stimuli used for any of the four stimulus modalities. The experimenter also controlled for olfactory stimuli that were similar in smell, for example, frankincense and eucalyptus or wintergreen and peppermint, if selected by the number generator, would not be assigned to the same participant. See Table 11 for an example of the contrived stimuli and names assigned for one participant.
Table 11

Example of a set of stimuli and contrived names used during stimulus-stimulus pairings and probe sessions for one participant.

<table>
<thead>
<tr>
<th>Contrived Name</th>
<th>Visual Stimulus</th>
<th>Auditory Stimulus⁹</th>
<th>Tactile Stimulus</th>
<th>Olfactory Stimulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yazy (7)</td>
<td>Ufo hover</td>
<td>Wool</td>
<td>Frankincense</td>
<td></td>
</tr>
<tr>
<td>Repum (8)</td>
<td>Honk-ding</td>
<td>Leather</td>
<td>Sweet orange</td>
<td></td>
</tr>
<tr>
<td>Epack (11)</td>
<td>Unscrew lightbulb</td>
<td>Bumpy cotton</td>
<td>Dill</td>
<td></td>
</tr>
</tbody>
</table>

⁹Auditory stimuli names reflected the experimenter's interpretation of the sounds used for data collection purposes.

Target Responses and Measures

Observing responses during stimulus-stimulus pairings (Independent variable) During the stimulus-stimulus pairings the experimenter presented all four stimulus modalities simultaneously on the table to the participant. The participant was given an opportunity to observe each stimulus and hear the experimenter say the name for the stimulus immediately after they observed it in its respective modality. During presentations of visual stimuli, the participant was instructed to look at the pictures that were placed on the table. During the presentation of auditory stimuli, the participant was required to look at the computer and not speak to allow for the auditory stimuli to be heard. For the tactile stimuli presentations, the participant was instructed to place their dominant hand in each hole of the canvas box to observe each of the tactile stimuli. The experimenter observed the participant’s hand from the opposite side of the box to ensure the participant made physical contact with each of the stimuli. During the olfactory stimulus presentations, the experimenter modeled a sniffing response while holding the
bottle under his nose and immediately presented the bottle under the participant’s nose for him or her to observe by imitating the sniffing response. Each participant received stimulus-stimulus pairings for each contrived name for a total of 9 pairings per session. Each stimulus-stimulus pairing consisted of 12 opportunities to hear the names of the stimuli (36 total opportunities) per session.

**Probes for untaught listener and speaker responses across stimulus modalities (Dependent variables).** Probes were conducted 2-hours after the participants received stimulus-stimulus pairings with the stimuli across the four modalities. The procedures used during all probe sessions were identical to the procedures used in Experiment I.

**Data Collection**

The data collection procedures in Experiment II were identical to those used in Experiment I. During the probe sessions, the experimenter recorded a plus to indicate correct responses and a minus to indicate incorrect responses to listener (i.e., selection) and speaker (i.e., vocal labeling) responses for each of the stimuli across the point and tact probes for each stimulus modality.

**Design**

The experiment consisted of repeated stimulus-stimulus pairings and probes across three dyads. All six of the participants received an initial stimulus-stimulus pairing at the onset of the experiment to identify whether they demonstrated naming for any of the stimulus modalities under investigation. The participants were then assigned to dyads such that Participants 1 and 2 received repeated pairings and probes until (a) the participants demonstrated naming across all four modalities; (b) demonstrated stability
across responses; or (c) decreases in correct responses due to extinction because of the unconsequated nature of the probe procedures. Once Participants 1 and 2 met any of the criteria, Participants 3 and 4 received began the repeated stimulus-stimulus pairings and probes. This design sequence was identical for Participants 5 and 6, such that by the end of the experiment each of the participants received an initial probe prior to the onset of the stimulus-stimulus pairing and probe sessions for all six participants and were reintroduced to the experimental procedures after each dyad met any of the pre-defined criteria. Refer to Figure 11 for an overview of the design procedures.
Interobserver Agreement

Interobserver agreement was collected in the same manner as in Experiment I. During Experiment II, a second observer conducted IOA in-vivo, during the probe sessions or via video recordings of the probe sessions. Inter-observer agreement was conducted for 55% of the listener and speaker probe sessions across all participants for all
four-stimulus modalities with a mean agreement of 99% (range 98% -100%). See Table 12 for a summary of the IOA for Experiment II.

Table 12

*Interobserver agreement (IOA) conducted for Experiment II*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Percentage of IOA conducted for each participant</th>
<th>Percentage of agreement between observers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57%</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>57%</td>
<td>98%</td>
</tr>
<tr>
<td>3</td>
<td>25%</td>
<td>100%</td>
</tr>
<tr>
<td>4</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>5</td>
<td>37.5%</td>
<td>100%</td>
</tr>
<tr>
<td>6</td>
<td>50%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Procedure**

**Stimulus-stimulus pairings.** Prior to all probe sessions the experimenter conducted stimulus-stimulus pairings during which the experimenter presented all four stimulus modalities simultaneously on the table to the participant. The participant was given an opportunity to observe each stimulus and hear the experimenter say the name for the stimulus immediately after they observed it in its respective modality. An example of a naming experience for a participant would be conducted in the following manner; the first experience would consist of the visual stimulus “tufest” being placed on the table in front of the participant, the participant was asked to look at the stimulus, and the experimenter said “this is tufest”, the participant was given 3-5-s to observe the stimulus before the experimenter presented the next modality for the participant to observe, for
example pressing a button for the auditory stimulus to play, and the experimenter said “this is tufest”, followed by a direction for the student to place their hand in the box and feel the tactile stimulus while hearing the experimenter say “this is tufest”, ending with the experimenter holding a dropper bottle up to the participant’s nose and saying “this is tufest”. All of the stimuli remained on the table after their presentation, such that the participant could see the visual stimulus during the auditory, tactile, and olfactory stimulus presentations. The conclusion of the fourth stimulus modality being presented constituted the end of one stimulus-stimulus pairing. Each participant received stimulus-stimulus pairings for each contrived name for a total of 9 pairings per session. Each stimulus-stimulus pairing consisted of 12 opportunities to hear the names of the stimuli (36 total opportunities) per session.

The experimenter did not deliver any consequences during the stimulus-stimulus pairings or the probe sessions. Following the naming experiences, the participant was taken back to their classroom and did not contact the stimuli until a 2-hour period had passed. See Figure 12 for a schematic drawing of the materials used during the stimulus-stimulus pairings.
Figure 12. Schematic drawing of participant’s view of the (a) visual; (b) auditory; (c) tactile; and (d) olfactory stimuli during the stimulus-stimulus pairings.

**Naming probes for visual, auditory, tactile and olfactory stimuli.** The probes were conducted in the same manner as Experiment I. Following a 2-hour break the experimenter conducted probes for listener and speaker responses to the stimuli across the four stimulus modalities. The experimenter conducted separate, unconsequated probes for listener and speaker responses to visual, auditory, tactile and olfactory stimuli. Each probe session consisted of 9 opportunities for each participant to respond as a listener, by pointing to identify a target stimulus when asked “point to ____” by the experimenter. The participants were also given 9 opportunities to respond as a speaker, by saying the name of the stimulus after the experimenter asked, "What is this?" (i.e., a total of 72 responses across the four modalities and two response topographies). Mastery criterion was set at 7 out of 9 correct responses or 78% correct responses or greater for each probe conducted for each stimulus modality. If a participant met criterion on either
the listener or speaker responses to a stimulus modality, but did not for the other (e.g. either listener or speaker), the experimenter continued to include the stimulus modality in subsequent probe sessions. The probes continued until any of the following conditions were met (a) if the participant’s responses demonstrated stable responding across three sessions, or (b) if the participant’s data demonstrated a descending trend in their responses, which was defined as extinction due to the unconsequated nature of the multiple exemplar naming experiences and probe sessions.

**Repeated stimulus-stimulus pairings and probes.** To investigate the effects of repeated pairing, the experimenter continued the procedures described above until the participants met the pre-determined criteria set by the experimenter. The repeated probes, were conducted identically to the initial probes with the same stimuli to test the effect of the pairings on subsequent probes. Mastery criterion was set at 78% correct responses or greater across one session, however, the repeated stimulus-stimulus pairings were terminated if the participant demonstrated stable responding across three sessions or if extinction occurred (i.e., correct responses began decreasing across sessions). The participants did not receive consequences during the stimulus-stimulus pairings or the probe sessions.
Results

The results indicate that the four participants demonstrated naming for one or more stimulus modalities following the repeated stimulus-stimulus pairing procedure. Participant 1 demonstrated full naming for visual stimuli after two sessions, the listener half of naming for auditory stimuli after two sessions, and the speaker half of naming for auditory stimuli after 6 sessions. Participant 2 demonstrated the listener half of naming for visual stimuli during the initial probe and the speaker half of naming after the sixth session, during which she also demonstrated the listener half of naming for tactile stimuli. Participant 3 demonstrated the listener half of naming for visual stimuli during the second probe session and the speaker half of naming for visual stimuli after the fourth probe session, but did not demonstrate naming for any of the additional modalities under investigation. During the initial probes, Participant 4 demonstrated full naming for visual, auditory, and olfactory stimuli; and full naming for tactile stimuli during the second probe session. Participant 5 demonstrated the listener half of naming for visual stimuli during the first probe session; the speaker half of naming for visual stimuli and auditory stimuli during the third session; the listener half of naming for tactile stimuli during the fifth probe session; and the listener half of naming for olfactory stimuli during the sixth probe session. Participant 6 demonstrated full naming for visual stimuli after the second probe session, additionally Participant 6 withdrew from the experiment after the second probe session. Figures 13, 14, and 15 provide a visual display of number of correct responses emitted during probe sessions across stimulus modalities for Dyad 1 (Participants 1 and 2), Dyad 2 (Participants 3 and 4), and Dyad 3 (Participants 5 and 6), respectively.
Figure 13. Dyad 1 (Participant 1 and 2) correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli. Note: Light to dark bars indicate each probe session (i.e. white bar indicates session 1; darkest bar indicates final probe session for each participant).
Figure 14. Dyad 2 (Participant 3 and 4) correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli. Note: Light to dark bars indicate each probe session (i.e. white bar indicates session 1; darkest bar indicates final probe session for each participant).
Figure 15. Dyad 3 (Participant 5 and 6) correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli. Note: Light to dark bars indicate each probe session (i.e. white bar indicates session 1; darkest bar indicates final probe session for each participant).
Figures 16, 17, and 18 display the same data, with the total number of correct listener and speaker responses across all stimulus modalities across probe sessions for Dyad 1, 2, and 3, respectively. The participants demonstrated increases in total correct speaker responses emitted across probe sessions.
Figure 16. Total number of correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli per session for Participants 1 and 2.
Figure 17. Total number of correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli per session for Participants 3 and 4.
Figure 18. Total number of correct listener and speaker responses emitted across visual, auditory, tactile, and olfactory stimuli per session for Participants 5 and 6.
To illustrate the differences in the discrepancies between the correct listener and speaker responses emitted for each participant during initial and final probe sessions, Figure 19 displays the total correct listener and speaker responses emitted during the initial and final probe sessions. Figure 20 displays the discrepancies between correct listener and speaker responses emitted during the initial and final probe sessions (See Figure 19) across all participants.

Four participants demonstrated decreases in the discrepancies between their correct listener and speaker responses during the final probe session. Two participants demonstrated discrepancies in the negative direction, emitting fewer correct listener responses than speaker responses during the final probe session. 2 out of six participants demonstrated increases for listener and speaker responses (i.e. Participants 2 and 5) and 3 out of six participants demonstrated increases in speaker responses, which mirrored the number of correct listener responses they emitted during the final probe sessions (i.e., Participants 1, 3, and 5).
Figure 19. Total number of correct listener and speaker responses emitted across stimulus modalities during initial and final probe sessions for Participants 1 and 2 (Top); Participants 3 and 4 (Middle); and Participants 5 and 6 (Bottom).
Figure 20. Differences between correct listener and speaker responses emitted across stimulus modalities during initial and final probe sessions for Participants 1 and 2 (Top); Participants 3 and 4 (Middle); and Participants 5 and 6 (Bottom). Note: Inverted bars indicate higher speaker responses were emitted than speaker responses during probe sessions.
The percentage of correct over total listener and speaker responses emitted by the six participants are displayed in Table 13. During the initial probe session, apart from Participant 4, Participants 1, 2, 3, 5, and 6 emitted 28% to 39% correct listener and speaker responses across listener and speaker responses to visual, auditory, tactile, and olfactory stimuli. During the final probe sessions Participants 1, 2, 3, 5, and 6 emitted 46% to 87% correct listener and speaker responses across the four stimulus modalities. During initial and final probe sessions Participant 4 emitted significantly higher correct listener and speaker responses compared to the other participants, he emitted 79% and 87% correct responses during the initial and final probe sessions, respectively.

Table 13

<table>
<thead>
<tr>
<th></th>
<th>Initial Probe</th>
<th>Final Probe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>26/72 (36%)</td>
<td>40/72 (56%)</td>
</tr>
<tr>
<td>Participant 2</td>
<td>20/72 (28%)</td>
<td>41/72 (57%)</td>
</tr>
<tr>
<td>Participant 3</td>
<td>20/72 (28%)</td>
<td>33/72 (46%)</td>
</tr>
<tr>
<td>Participant 4</td>
<td>57/72 (79%)</td>
<td>63/72 (87%)</td>
</tr>
<tr>
<td>Participant 5</td>
<td>23/72 (32%)</td>
<td>50/72 (69%)</td>
</tr>
<tr>
<td>Participant 6</td>
<td>28/72 (39%)</td>
<td>33/72 (46%)</td>
</tr>
</tbody>
</table>
Discussion

The results from Experiment II demonstrated that the repeated stimulus-stimulus pairing procedure resulted in the demonstration of naming for four of the six participants. The nature of the repeated pairings, during which a visual stimulus that functioned as a reinforcer for observing, was paired with auditory, tactile, and olfactory stimuli may have functioned as a higher-order conditioning procedure that transferred the reinforcing properties of the visual stimuli to the other modalities. The simultaneous presentation of visual stimuli, auditory stimuli, tactile stimuli, and olfactory stimuli with the contrived names functioned to condition new observing responses to previously neutral stimulus modalities, thus establishing new relations between the name and stimulus characteristics across probe sessions. Three participants (Participants 1, 4, and 5) demonstrated full naming for one of the four stimulus modalities, and two participants (Participants 2 and 5) demonstrated only the listener half of naming for one of the four stimulus modalities.

Five of the participants demonstrated increases for correct speaker responses from the initial probe session to the final probe session (Figure 19). Speaker responses accrued across probe sessions for Participants 1 through 5 (Figure 16, 17, and 18), indicating that speaker responses joined listener responses, which remained relatively stable for all participants throughout the experiment. These results support the findings of previous studies on naming, that have shown that there is a joining of listener and speaker responses when children acquire the naming capability (Cahill & Greer, 2014; Fiorile and Greer, 2007; Gilic and Greer, 2011; Greer, Stolfi, Chavez-Brown, and Rivera-Valdez, 2005; Greer, Stolfi, and Pistoljevic, 2007; Helou-Care, 2008; Lo, 2016; Pistoljevic, 2008). Although some participants did not demonstrate full naming, according to the
criteria set by the experimenter, the experimenter did find that most of the participants acquired one or two of the names during the probe sessions, but did not meet the criteria of 7/9 correct responses. These additional anecdotal findings indicate that acquisition was occurring for some, but not all of the stimulus names at slower rates. Some of the stimuli may have acquired more reinforcing stimulus control over the participants’ observing responses. The discrepancies between the correct listener and speaker responses emitted during the initial and final probe sessions provide additional support for the argument that naming (i.e. joining of listener and speaker responses) did occur across participants, but the arbitrary criteria set by the experimenter may have limited the interpretations of the findings by excluding participants who emitted 6 out of 9 correct responses from the other participants that were identified as demonstrating naming.

Participant 3 did not demonstrate naming during the repeated probe sessions, however, she did demonstrate acquisition of listener responses for 2 out of 3 contrived names (i.e., 6/9 correct listener responses) for olfactory stimuli during the final probe session, indicating that untaught listener responses accrued as a function of the stimulus-stimulus pairings for some, but not all, of the stimulus names. Similar results were observed for Participants 2 and 5, with both participants demonstrating the listener half of naming for tactile stimuli and Participant 5 demonstrating the listener half of naming for olfactory stimuli (Figures 18 and 20).

Although most of the participants did not demonstrate naming for all of the stimulus modalities under investigation, the results from Experiment II did demonstrate that transformation of stimulus function occurred for four of the six participants (Figure 19). The overall increases in correct speaker responses emitted during the final probes for
Participants 1, 2, 3, and 5 provide support for the increase in correct speaker responses following the repeated stimulus-stimulus pairings, which closely matched the number of correct listener responses emitted by the four participants. When looking at the total number of correct listener and speaker responses emitted as well as the discrepancies between these responses during initial and final probe sessions (Figures 18 and 19, respectively), Participants 1 and 3 demonstrated stable numbers of correct listener responses during initial and final probe sessions, while also demonstrating increases in correct speaker responses. Participants 2 and 5’s results provide additional support by demonstrating that increases in both listener and speaker responses were observed during the final probe session, indicating both acquisition and joining of listener and speaker responses.

The results of Experiment II provide evidence for the use of repeated stimulus-stimulus pairings as an instructional intervention for students who demonstrate naming for visual stimuli for acquiring listener and speaker responses to multiple forms of a single stimulus. The results demonstrated that some participants learned untaught listener and speaker responses to stimulus modalities that they did not previously have in their repertoire, indicating transfer of stimulus control from visual stimuli to other stimulus modalities as a function of pairing the name of a stimulus with the observing response emitted by the participant, while other stimulus properties were present (i.e., the stimulus is available to be seen, heard, touched, and smelled). Recent research has identified conditioned reinforcement for 2-dimentional stimuli as a behavioral developmental cusp (Rosales-Ruiz & Baer, 1997) which allows children to learn generalized match to sample responses as well as select to look at books when in a free play setting (Han & Greer,
Subsequent studies have expanded upon conditioned reinforcement for 2-dimensional stimuli by demonstrating that unconditioned stimuli, such as auditory sounds, can be conditioned as reinforcers through stimulus-stimulus pairings in which a picture is presented simultaneously with a sound (Lo, 2016; Longano & Greer, 2015). The results of the current experiment expand upon the potential conditioning histories that may be established to teach new reinforcers, thereby establishing the necessary observing responses across multiple sense modalities. The expansion of observing responses to tactile and olfactory allow for 1) additional potential reinforcers to pair with new vocabulary, and 2) evidence for the use of multimodal approaches to language learning in early childhood.

From an educational perspective, the findings highlight the importance of determining which stimulus properties function as conditioned reinforcers for students’ observing. The results demonstrated overall increases in correct responses occurring from the initial probe session to the final probe session. However, decreases were also observed throughout the experiment for some of the participants’ responses to specific stimulus modalities, indicating a potential extinction process occurred because of the unconsequated nature of the probe sessions. Participant 1 demonstrated decreases for speaker responses to auditory stimuli, and listener responses to tactile stimuli during some of her probe sessions. Participant 2 demonstrated decreases for correct listener responses to tactile stimuli as well as decreases for correct speaker responses to tactile, auditory, and olfactory stimuli. Participants 4 and 5 demonstrated decreases for listener responses to olfactory and tactile stimuli, respectively. These decreases are argued to be a result of extinction (Pavlov, 1927), because of the subsequent sharp increases in correct
responses emitted for these stimuli occurring after a weekend and week-long school break for the participants demonstrated what Pavlov (1927) discovered as spontaneous recovery. Spontaneous recovery occurs after the passage of time following extinction due to non-reinforcement, during which the initially learned behavior increases to pre-extinction levels. Introducing greater time delays between the time of extinction and reintroduction to an experimental procedure provides the opportunity for greater spontaneous recovery (Rescorla, 2004). Participants 1, 2, and 3 demonstrated spontaneous recovery following a break from the experiment due to holidays. These findings reveal the importance of determining which stimulus modalities may function to accelerate or potentially hinder the acquisition of new words. As Blackledge (2003) illustrated the potential of stimuli to acquire negative reinforcement properties with the example of the word snake eliciting responses such as avoidance/escape; so too can a stimulus such as the smell of dill produce avoidance responses which prevent its name, “Remoke,” from being acquired as a listener or speaker and potentially pairing all stimulus modalities under the class “Remoke” as negative reinforcers, eliciting avoidance responses. It is imperative that teachers, parents, and other caregivers provide rich language experiences while also considering the reinforcing properties of the various modalities that comprise a single stimulus.
CHAPTER IV
GENERAL DISCUSSION

Summary of Findings

The results of the current experiments add to the existing literature on the development of conditioned reinforcement for observing responses which lead to the incidental acquisition of language. In an extension of the recent findings in Naming research involving newly conditioned observing responses to auditory stimuli (Longano & Greer, 2015; Lo, 2016), the first experiment provided a controlled comparison of the demonstration of naming across stimulus modalities by including tactile and olfactory stimuli as dependent measures of naming. The children demonstrated naming for different stimulus modalities at different rates. While some children in Experiment II demonstrated stimulus relations for stimuli that were paired with conditioned reinforcers, which facilitated the development of additional observing responses for other modalities, other children failed to acquire the names of some stimuli when the stimulus modalities shared the same name. More so, there were opposite effects on language acquisition, indicating some stimuli acquired punishing stimulus control over responding.

Experiment I provided a comparison of naming across four stimulus modalities for six participants and demonstrated differential responding to visual, auditory, tactile, and olfactory stimuli across participants. In Experiment I, all of the participants demonstrated naming for a modality other than visual after a second naming experience and probe. Although all of the participants demonstrated naming for visual stimuli after two sessions, this constituted a total of ten opportunities to hear the name of each stimulus across both sessions. Other naming studies, including those requiring the
participants to demonstrate mastery of match-to-sample responses (i.e., a variation of the naming experience) prior to naming probes, provided well over 20 opportunities for the participants to hear each stimulus name. It is not clear from the results of Experiment I whether repeated naming experiences would have resulted in the eventual demonstration of naming for each of the participants, however, the results from previous naming studies have used the results of the final probe session to determine if naming accrues as a function of specific instructional manipulations (Cahill & Greer, 2014; Fiorile and Greer, 2007; Gilic and Greer, 2011; Greer, Stolfi, Chavez-Brown, and Rivera-Valdez, 2005; Greer, Stolfi, and Pistoljevic, 2007; Helou-Care, 2008; Lo, 2016; Pistoljevic, 2008).

Thus, the results of Experiment I are consistent with prior research.

In Experiment II, the demonstration of naming across four of the participants after repeated stimulus-stimulus pairings add to the existing literature on the potential higher-order conditioning processes that occur when conditioned reinforcers (e.g., visual stimuli) are paired with neutral or unconditioned stimuli (e.g., sounds, textures, and smells). Three participants demonstrated full naming for auditory stimuli; one participant demonstrated full naming for tactile stimuli, with two additional participants demonstrating only the listener half of naming; and one participant demonstrated full naming for olfactory stimuli, while another demonstrated only the listener half. Similar to findings from previous naming studies, the participants in Experiment II demonstrated sequential increases in the total number of correct speaker responses across probe sessions, which eventually matched or closely matched the number of correct listener responses they emitted across probe sessions. The number of correct listener responses emitted across sessions remained relatively stable indicating that some participants readily acquired the
names of one or two of the stimuli as listeners, and the speaker responses to these stimuli gradually joined following each pairing. This further supports the argument that the listener repertoire is a necessary component for the acquisition of novel names as a speaker (Greer & Keohane, 2006; Greer & Ross, 2008; Greer & Speckman, 2009; Longano & Greer, 2010; Stemmer, 1996).

Experiment II also demonstrated that the repeated stimulus-stimulus pairings had the opposite effect on language acquisition for some of the participants, resulting in the emission of avoidance responses to particular stimuli, and subsequently affecting the participants’ acquisition of modality specific words. Similar to the example of the stimulus *snake* evoking an emotional response of fear and subsequent aversion to the woods after snake and woods are paired (Blackledge, 2003), the results of the probe sessions for some of the participants demonstrated decreases in responding potentially due to the unpleasant properties of some of the stimuli. Some of the participants emitted avoidance responses (e.g., holding their noses, or saying “I don’t like that one”) for the olfactory stimuli; frankincense, eucalyptus, basil, pine, and dill. The participants may have demonstrated fewer correct responses to these stimuli during probe sessions because of the stimulus properties of some of the olfactory stimuli were more unpleasant than others (e.g., eucalyptus, frankincense, dill were stimuli that elicited avoidance responses from the participants) and the subsequent avoidance responses interfered with the participants’ attention to the name of the stimuli. Another potential explanation for the decreases in responding could have been due to the higher response effort for some of the observing responses (i.e., tactile and olfactory) and the lack of reinforcement delivered to participants during the probe sessions. The sudden increase in correct responses for
Participants 1, 2, and 3 demonstrated spontaneous recovery of their responses to tactile and olfactory stimuli after a break from school, which occurred in the middle of the experiment while the participants were receiving repeated stimulus-stimulus pairings and probes. These findings reveal the importance of determining which stimulus modalities may function to accelerate or potentially hinder the acquisition of new words.

Participant 3 did not demonstrate naming for auditory, tactile, or olfactory stimuli during the probes in Experiment I and after the repeated stimulus-stimulus pairings in Experiment II. Participant 3 was taken out of school for vacation after the fourth probe session, thus she was not given the same number of opportunities the other participants received to demonstrate (a) naming, (b) stability, or (c) decreases in responding. Participant 3 did however demonstrate 6 out of 9 correct listener responses for olfactory stimuli during her fourth probe session, demonstrating the acquisition of the names for two out of the three stimuli. Participant 3 may have demonstrated the listener half of naming for olfactory stimuli if she had continued the experiment.

**Conditioned Reinforcement and Naming**

The role of conditioned reinforcement in the development of observing responses to stimuli serves as the basis for language development. Extensive research has demonstrated that newly acquired conditioned reinforcers are necessary cusps which allow children to contact parts of their environment that they would not if the cusp was missing (Delgado Greer, Speckman, & Goswami, 2009; Du, Broto, & Greer, 2015; Greer, Becker, Saxe, & Mirabella, 1985; Greer & Han, 2014; Greer, Pistoljevic, Cahill, & Du, 2011; Keohane, Luke, & Greer, 2008; Longano & Greer, 2015; Nuzzolo-Gomez, Leonard, Ortiz, Rivera, & Greer, 2002). There are several pre-verbal foundational cusps...
that have been identified in the literature that are necessary for the acquisition of naming to occur (Greer, et al., 2005; Greer & Ross, 2008; Greer & Speckman, 2009). The results of the current studies indicate additional pre-verbal cusps that include observing responses for tactile and olfactory stimuli. Longano and Greer (2015) and Lo (2016) provided empirical support for this assertion, however the current experiment provides the first indication that observing responses for visual, auditory, tactile, and olfactory stimuli accrue at different rates for both neurotypical children and children with a diagnosis of Autism. Furthermore, for children who demonstrate naming for visual stimuli, the other stimulus features may not acquire stimulus control for listener or speaker responses when a visual stimulus is presented with other modalities.

**Blocking Effect**

The nature of the stimulus-stimulus pairings used in Experiment II may have had a blocking effect (Kamin, 1969). The blocking effect is a phenomenon which is used to describe findings which demonstrate that when a conditioning history is established with one stimulus, that history interferes or blocks the conditioning of a second, redundant stimulus when the two stimuli are simultaneously presented as a compound (Rehfeldt et al., 1998). As was the case in Experiment II for some participants, the stimulus-stimulus pairings of one or two stimuli which functioned as conditioned reinforcers for observing with the other unconditioned stimuli could have compounded the blocking effect that has been investigated and found to occur with two stimuli being paired. The implications of these findings suggest that the temporal contiguity between the stimulus presentations and their names may not be sufficient for conditioning to occur across stimulus modalities.
Educational Implications of Findings

The implications of the findings demonstrate the need for educators to clearly identify the optimal conditions to provide children new language experiences. In order to ensure that a student is given the best possible conditions to learn the names of things, a teacher must first identify the roles multiple modalities have in a child’s repertoire. The results of both of the experiments highlight the possibility of enhancing language learning experiences by bringing attention to the multiple characteristics that can be observed with a single stimulus. Preschoolers are bombarded with sensory stimuli throughout the day, yet, in the current experiment, not all stimuli are attended to and the acquisition of novel words for things may be lost. Although Experiment II was a demonstration of naming, it provided evidence for the multiple opportunities children require to learn the names of classes of stimuli. If students have naming in their repertoire, teachers are likely to assume that they are also learning the name “popcorn” for example, for the sound, texture and smell of the popcorn, which the current findings demonstrate may not be the case.

Limitations and Future Research

There were some limitations to the present set of experiments. The lack of reinforcement or corrections delivered throughout the experiment may have affected the participants’ responding during probe sessions. Consequently, the withdrawal of Participant 6 from the experiment following the second probe session may have occurred because of this limitation. All of the participants functioned at advanced levels of verbal behavior for their age and had instructional histories of reinforcement for correct responses and corrections for incorrect responses, thus, throughout the experiment most participants asked the experimenter if their responses were correct. The purpose of the
experiment was to establish naming indirectly through stimulus-stimulus pairings and not through direct reinforcement contingencies, which could be addressed in future studies. Previous studies have used naming experiences that involve reinforcement contingencies for match-to-sample responses prior to naming probes being conducted (Fiorile & Greer, 2007; Gilic & Greer, 2011; Greer, Stolfi, Chavez-Brown, & Rivera-Valdes, 2005; Greer, Corwin, & Buttigieg, 2011; Greer, Stolfi, & Pistoljevic 2007; Pistoljevic, 2008). Future studies could provide naming experiences through match-to-sample instruction, where the names of the stimuli are heard but the matching response involves a visual, auditory, tactile, or olfactory response for which the participant is reinforced or given a correction. An experiment of this nature would investigate whether the pairing of reinforcement with the name of the stimulus modality would condition novel observing responses to that modality and result in naming.

The probe procedures used in Experiment I could be conducted to determine if naming is present across modalities for children who have not been assessed for naming or who do not demonstrate naming for visual stimuli. The procedures used in Experiment I could identify stimulus modalities that are conditioned reinforcers and use the repeated stimulus-stimulus pairing procedure used in Experiment II, and by Longano and Greer (2015) and Lo (2016) to condition visual stimuli as reinforcers.

Additionally, the 2-hr time period between the naming experiences, as well as stimulus-stimulus pairings in Experiment II, and the subsequent probe sessions was selected due to the use of similar passages of time in previous research on naming. The 2-hr time period is a standardized procedure in the school in which the experiment was conducted, therefore the procedures used in the current set of experiments were
consistent with the procedures used by the participants’ teachers when they assessed the students for naming.

The findings of both experiments could also be extended in future studies to include the acquisition of naming for children who function at lower levels of verbal behavior. Although researchers have suggested that to be truly verbal, a child must have social conditioned reinforcers (Greer & Du, 2015). For younger children who do not readily emit tacts (i.e., vocal labels) for things in their environment, but do have speaker repertoires, a well-controlled study could replicate these findings by replacing tact and intraverbal responses with mands. To illustrate this I will use the popcorn example; If a child watches an adult place a bag of popcorn in the microwave and hears it popping, then smells the popcorn as it cooks, and finally feels the warm popcorn when it is placed in his or her hand, the child may not necessarily hear the word “popcorn” at the same time as he emits each of these observing responses, however the child may hear the word popcorn at some point during the interaction. If at another point in time, and without direct instruction, the child hears popping, smells butter cooking, or feels a texture resembling that of popcorn, and says “popcorn” as a mand (i.e., request), would this not be an instance of naming across the senses? The reinforcing properties of the popcorn itself (e.g., the gustatory properties of the butter and salt) may also function as conditioned reinforcers that pair with the multiple modalities present in the popcorn. The procedure used in Experiment II could be used with children who do not have the social conditioned reinforcers necessary for the emission of tacts. Children may not demonstrate speaker responses due to a lack of conditioned reinforcement for adult attention and approval, however mand responses could replace tact responses during speaker probes for
children with lower levels of verbal behavior. Future researchers could potentially induce new forms of naming for children who are missing prerequisites for tact responses during traditional naming probes.

**Conclusion**

Longano and Greer (2015) argued that there may be multiple types of naming for stimuli across visual, auditory, tactile, olfactory and gustatory modalities. The experiments described in this paper provide the first experimental investigation of tactile and olfactory stimulus modalities in relation to the naming capability. The results are consistent with previous findings of the development of new conditioned reinforcers for observing as a function of stimulus-stimulus pairings and demonstrations of naming for novel stimulus modalities (Longano & Greer, 2015; Lo, 2016).

The current experiment also presents an interesting basis for the future investigations of the number of opportunities necessary for children to acquire new language. By controlling for the modality of the stimuli while keeping the names consistent, Experiment II demonstrated that the demonstration of naming may be dependent on the number of opportunities a child must observe and hear the name of a stimulus. This highlights some inconsistencies within the literature regarding the optimal number of opportunities participants are given to hear stimulus names before naming probes are conducted, which is necessary for standardizing the criteria for the presence of the naming capability.

The acquisition of untaught listener and speaker responses to stimuli is a necessary repertoire for students entering school. Most of the instruction in schools involves indirect or no contact with reinforcement contingencies and exposure to multiple
stimulus modalities. Students who can acquire the names of stimuli across modalities and demonstrate identification of those stimuli as listeners (i.e., pointing to) and speakers (i.e., labeling) will also demonstrate a faster and larger acquisition of new vocabulary. The results of the current experiment demonstrate that there is variability in the acquisition of names across stimulus modalities and that instructional histories of pairings with stimuli that select out observing responses can lead to the emergence of new stimulus relations for children.
References


Greer, R. D. & Speckman, J. (2009). The integration of speaker and listener responses: A


Pereira-Delgado, J., Greer, R. D., Speckman, J., & Goswami, A. (2009). Effects of conditioning reinforcement for print stimuli on match-to-sample responding in


expansion of the testing paradigm. *Journal of Experimental Analysis of Behavior, 37*(1), 5–22.


