The Relationship Between Bidirectional Naming, Derived Relations, and Non-Arbitrary Relations

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ABSTRACT

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In 2 experiments, I analyzed relations between the presence of Bidirectional Naming (BiN) and the establishment of arbitrary and non-arbitrary relational responses. In Experiment I, I analyzed the presence and strength of correlations between Bidirectional Naming and the establishment of derived relations for 31 preschool students. For Bidirectional Naming, the participants' responses to both familiar and unfamiliar stimuli were measured; familiar stimuli were defined as spoken and visual stimuli that may be commonly present in the participants' environment, while unfamiliar stimuli were contrived spoken and visual stimuli that were not customarily present in the participants' environment. For relational responses, a non-arbitrary relation was defined as a relation that can be made based on the formal characteristics of the stimuli, while an arbitrary relation would be based on verbally mediated contextual cues. Data from this experiment showed there was an overall positive correlation between the demonstration of Bidirectional Naming and the establishment of derived relations, $r = .847$, $p < .001$. Moreover, there was a strong positive correlation between Bidirectional Naming with unfamiliar stimuli and arbitrarily derived relations, $r = .823$, $p < .001$. In Experiment II, I studied the establishment of arbitrary visual-visual and auditory-visual relations for 18 preschool students. The participants were split into 3 equal groups based on their degree of Bidirectional Naming; the groups consisted of 6 participants that demonstrated Bidirectional Naming, 6 participants that demonstrated Unidirectional Naming (UniN), and 6 participants that demonstrated a low degree of Bidirectional Naming. A comparison of the mean correct responses, between experimental

groups, showed a significant difference for auditory-visual relations, $F(2,15) = 36.63$, $p < .001$, as well as visual-visual relations, $F(2,15) = 4.11$, $p = .038$. These data suggest that simpler (i.e., auditory-visual) derived relations are present with Unidirectional Naming; however, the joining of the listener and speaker repertoires (i.e., Bidirectional Naming) may be necessary for the development of more complex (i.e., visual-visual) derived relations. The results of these experiments suggest strong associations between the incidental acquisition of words and the incidental acquisition of language relations. The results also provide more evidence for how the establishment of Bidirectional Naming may lead to an individual learning at accelerated rates and in new ways.

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DEDICATION

I dedicate this work to my students and my amazing nieces and nephews. I hope that each of you fearlessly and unapologetically pursue your wildest dreams.

CHAPTER 1

INTRODUCTION AND REVIEW OF LITERATURE

In different analyses of language, the discourse, interventions, measurement, and definitions often differ, but one idea that is consistent within each perspective is a developmental stage where a child's language increases rapidly (Longano & Greer, 2015; McMurray, 2007). McMurray (2007) pinpoints the second postnatal year as the starting point for this dramatic acceleration in word learning; within this developmental period, children are learning words at a faster rate than they are taught through direct instruction. The field of Applied Behavior Analysis views this accelerated rate in word learning as the acquisition of untaught relations. Sidman’s (1971) description of stimulus equivalence, Hayes, Barnes-Homes, and Roche’s (2001) Relational Frame Theory (RFT), and Horne and Lowe’s (1996) naming theory all denote concepts of language progression that attempt to explain the development of untaught relations. Collectively, while there is an abundance of conceptual and empirical research on each of these theories separately, there remains a gap in empirical research on the interaction of BiN, as a developmental cusp, and arbitrary/non-arbitrary relational responses. Therefore, the following experiments aim to provide a further analysis into correlations between BiN and the demonstration of relational response repertoires, as measured through the frame of coordination.

I will review the conceptual and empirical research on BiN as an independent and dependent variable, as well as analyze the proposed source of reinforcement for BiN. I will then discuss other theories on the development of untaught relations beginning with the work of Sidman (1971) and how it has led to more recent accounts of untaught relations, like Relational Frame Theory (RFT) (Hayes & Barnes-Holmes, 2004). This analysis will briefly detail empirical research that has been conducted on establishing derived relations, with preschool and elementary aged students, and will synthesize conceptual and empirical research between BiN and derived relations. Finally, I will discuss gaps I believe are present in the current literature and propose my research questions for the present experiments.

Unidirectional and Bidirectional Naming

Common and Intraverbal Naming

Horne and Lowe (1996) initially defined naming as "a higher order bidirectional behavioral relation that (a) combines conventional speaker and listener behavior within the individual, (b) does not require reinforcement of both speaker and listener behavior for each new name to be established, and (c) relates to classes of objects and events" (p. 207). Horne and Lowe's theory of naming begins with the development of listener behaviors, which are selected out and reinforced in utero; later these behaviors develop into what they identified as two fundamental types of naming: common and intraverbal. Common naming can be described as when different exemplars, of the same stimulus, evoke listener and speaker behaviors because they are within the same stimulus class (Miguel, 2016). Intraverbal naming describes when children learn word combinations, following multiple exposures of their caregiver pairing the words together (Horne & Lowe, 1996). Horne and Lowe believed that in hearing these word combinations, the child's self-echoic repertoire frequently repeats these relations and establishes a one-directional intraverbal (e.g., knife-fork), into a two-directional intraverbal (e.g., fork-knife); later, other words (e.g., spoon) that are evoked by these stimuli may also join the relation or stimulus class (i.e., utensils). Thus, learning the name of a stimulus may allow a child to extend the name to other stimuli within the same functional stimulus class. Horne and Lowe stated:

> Naming incorporating as it does bidirectional relations between a single verbal response and a class of objects or events, can establish and maintain more than one level of functional equivalence…if taught a common name for members of a class of physically different stimuli, a child may, when presented with a single exemplar of the class select other class members without having ever previously been directly trained to do so (p. 205).

In extending Horne and Lowe's naming theory (1996), the Verbal Behavior Development Theory (VBDT) began to study naming as a developmental cusp that leads to dramatic changes in the way an individual acquires language; however, they instead referred to the cusp as Naming to differentiate it from the tact repertoire or naming loop described by Horne and Lowe. Later Miguel (2016) urged the use of the name Bidirectional Naming (BiN) to separate the technical verbal behavior term from the colloquial use of the word. Within this review of the literature, naming will be used to refer to the theory as posited by Horne and Lowe, and Bidirectional Naming (BiN) will be used to refer to the developmental cusp defined by VBDT.

Bidirectional Naming as a Verbal Developmental Cusp and Capability

Bijou and Baer (1961) identified behavioral developmental cusps as a behavior change that reveals new environments, motivating operations, contingencies, responses, and stimulus control to an individual's repertoire. Typically, when a behavioral cusp is induced, "the individual's repertoire expands…[and] it [i.e., their repertoire] encounters a differentially selective maintenance of the new as well as some old repertoires, and perhaps leads to some further cusps" (Rosales-Ruiz & Baer, 1997, p. 534). A primary example of a behavioral cusp is learning to crawl; once a child has learned to crawl, s/he gains access to a multitude of environmental contingencies that they could not independently access prior to reaching that milestone. Proponents of the VBDT have also identified verbal development cusps, as behaviors that allow children to contact new contingencies and learn in ways they could not before (Greer & Ross, 2008; Greer & Speckman, 2009). BiN, as described through VBDT, builds upon Horne and Lowe's theory (1996) while also emphasizing it as a verbal developmental cusp in which children can begin to learn language incidentally. The VBDT also identifies BiN as a speaker-as-own-listener cusp, which is defined as a verbal developmental cusp that demonstrates when an individual behaves as both a listener and a speaker within the same skin. The presence of speaker-as-own-listener repertoires is demonstrated if a participant has verbal governance over their own behaviors (Greer & Keohane, 2005; Greer & Ross, 2008; Speckman & Greer, 2009); and thus, this individual would demonstrate a correspondence between non-vocal and vocal-verbal behavior. In VBDT, BiN and other speaker-as-own-listener cusps like self-talk (Lodhi & Greer, 1989) and say-do correspondence (Baer, Detrich, & Weninger, 1988), define the onset of an individual becoming truly verbal. Children with these cusps in their repertoire often demonstrate sequelics (i.e., a social exchange with 2 volleys between a listener and a speaker), conversational units (i.e., a social exchange with 3 volleys between a listener and speaker), and audience control (i.e., regulation of speaker behavior based on the audience present) (Farrell, 2017; Greer & Keohane, 2005; Greer & Ross, 2008; Speckman & Greer, 2009).

As described through the VBDT, an individual with BiN acquires language through an instance of joint attention with a caregiver and the environment; these exposures are called naming experiences. During a naming experience, the child and caregiver may be observing a visual stimulus together (e.g., a blue jay) while the caregiver produces the vocal name for that stimulus. After this experience, when the stimulus is later seen in their environment, a child with Unidirectional Naming (UniN) demonstrates listener (i.e., pointing or identifying a blue jay), and a child with Bidirectional Naming (BiN) demonstrates both listener and speaker responses (i.e., tacting or emitting an intraverbal tact). In that way, BiN results in multiple responses after direct exposure, and thus BiN demonstrates one way we may incidentally learn language.

Bidirectional Naming as an Independent Variable

When BiN is present, an individual can learn in new ways; in addition, the developmental cusp changes the way the individual accrues reinforcement from their environment. More specifically, the induction of BiN also signifies the acquisition of new reinforcers and motivating operations that allow the child to learn in new ways. Greer, Corwin, and Buttigieg (2011) tested the effects of the presence of BiN on the participants' rate of learning when the instruction was delivered through instructional demonstration learn units (i.e., teacher modeling). The data from this study demonstrated that participants who lacked BiN did not learn from instructional demonstration learn units. The findings from Hranchuk (2016) were also consistent with Greer et al., (2011), in demonstrating that children with BiN learn at an accelerated rate under conditions that used instructional demonstration learn units. The findings from these experiments showed changes in the rate of learning after demonstration of BiN, and thus they suggest more effective instruction for children with BiN. Furthermore, these data show that speaker-as-own-listener repertoires, like BiN, are the foundation for the development of other advanced verbal repertoires (e.g., reading comprehension and functional writing), and a predictor for an individual's academic success in educational settings (Corwin & Greer, 2017; Frias, 2016; Greer, 2008; Greer & Speckman, 2009).

Bidirectional Naming as a Dependent Variable

When an individual does not demonstrate BiN, they require direct learn units in each response topography (i.e., listener-match/point and speaker-tact/intraverbal tact), and thus do not acquire language incidentally (Longano & Greer, 2010). Therefore, the absence of BiN requires increased direct instruction and subsequently more time to expand the child's repertoires. Contrastingly, the presence of BiN leads to an expanded community of reinforcers (i.e., contact with more reinforcement) and thus learning in multiple new ways. In some cases, BiN may be acquired incidentally through the child's typical language experiences. However, when the developmental cusp is not present, as has often been demonstrated for children with language delays, English language learners, and children from economically disadvantaged households (Corwin & Greer, 2014; Greer & O'Sullivan, 2007), it may be induced. Following Horne and Lowe's (1996) initial conceptual work on naming, many other studies have been conducted on how to induce BiN for children with language delays.

Multiple exemplar instruction. Multiple Exemplar Instruction (MEI) is a pedagogical sequence that can be employed to teach abstractions across various stimuli and responses. These abstractions are taught through a rotation of different trial types, across relevant dimensions, to join responding. There are a variety of MEI procedures that vary different aspects of the instruction to teach an array of repertoires; some being MEI across irrelevant characteristics to teach essential stimulus control (Engelmann & Carnine, 1991; McGuinness, 2004; McGuinness, 2005), MEI across motivating operations to induce transformation of establishing operations across mands and tacts (Singer-Dudek, Park, Lee, & Lo, 2017), MEI across saying and writing to establish transformation of stimulus function across written and vocal responses (Eby, Greer, Tullo, Baker, & Pauly, 2010), and MEI across listener and speaker responses to induce BiN (Fiorile & Greer, 2007; Gilic & Greer, 2011; Greer, Stolfi, & Pistoljevic, 2007).

Multiple Exemplar Stimulus Instruction (MESI) involves the rotation of various target stimuli that contain the essential stimulus to be abstracted, while also varying the irrelevant dimensions. The goal of MESI is to teach direct stimulus control, so the student also responds to novel untaught exemplars (TABA, unpublished manuscript). Therefore, when using MESI to teach shapes the presentation of the positive exemplar may vary in the irrelevant dimensions, that is size, object, texture, color, and dimensions. In addition, the negative exemplars should have varying stimuli, with some being vastly different and others being a close parallel to the target stimulus (TABA, unpublished manuscript). Multiple Exemplar Instruction across saying and writing involves writing and saying letters of a word, resulting in joint responding across these repertoires. This developmental cusp is crucial in the acquisition of an adequate spelling repertoire, being that only a small set of words can be taught through direct instruction (TABA, unpublished manuscript). Multiple exemplar across motivating operations for mands and tacts involves the rotation of mand and tact opportunities, along with the manipulation of their corresponding motivating operations. The utilization of this procedure has led to the emergence of untaught mands and tacts which also results in accelerated increases in an individual's verbal repertoire (Singer-Dudek et al., 2017).

MEI across listener and speaker responses is a different procedure which aims to teach multiple responses for each stimulus to join the individual's listener and speaker repertoires (Longano & Greer, 2010). The MEI protocol involves the rotation of listener responses (i.e., match & point) and speaker responses (i.e., tact and intraverbal tact), with multiple exemplars of unknown stimuli. The match response involves the participant matching the target exemplar to a corresponding exemplar in a field of three; the stimuli presented involve one target stimulus and two non-target stimuli that are within the same stimuli set. The point response involves the participant identifying the target exemplar in a field of three; the field of stimuli used during this probe trial mirrors the same configuration of target and non-target stimuli described during the match response. A tact response involves the participant saying the name for the presented stimulus after no vocal antecedent was presented. An intraverbal tact response involves the participant saying the name for the presented stimulus, after a vocal antecedent. Current empirical research has demonstrated MEI, across listener and speaker responses, as an effective procedure for inducing BiN for preschool students with limited verbal repertoires (Fiorile & Greer, 2007; Gilic & Greer, 2011; Greer et al., 2007). MEI has also been demonstrated as a more effective intervention than Single Exemplar Instruction (SEI) (i.e., instruction in which responses are not rotated, instead they are taught separately in massed sessions) for the emergence of untaught listener and speaker responses (Greer et al., 2007).

Other interventions to induce BiN. Along with MEI, other interventions have proven effective in inducing BiN for numerous children with different verbal developmental capabilities. These interventions include stimulus-stimulus pairing, Intensive Tact Instruction (ITI), and the auditory match-to-sample protocol.

Longano and Greer (2015) conditioned auditory and visual stimuli, and then paired them with neutral stimuli, to analyze whether the neutral stimuli would acquire reinforcing properties. The intervention used a classical conditioning procedure that paired edibles, vocal praise, or playful physical contact with the participants' demonstration of observing responses (i.e., looking or listening) to the neutral stimuli for the first phase, and then paired visual and auditory stimuli together for the second phase. The conditioning procedure involved the rotation of pair trials and test trials, in which pair trials involved the presentation of neutral stimuli and reinforcers and the test trial involved the withdrawal of the reinforcer to assess whether the participant continued to emit the observing response independently. The purpose of this experiment was to investigate conditioned reinforcement, for observing responses, as a possible source of reinforcement for BiN.

The data from Longano and Greer (2015) demonstrated increases in participants' listener and speaker responses for BiN, as well as conditioned reinforcement for both response topographies. This study not only showed that a stimulus-stimulus pairing procedure might be used to induce BiN but also demonstrated the echoic as a critical component in the source of reinforcement for BiN.

Intensive Tact Instruction (ITI) is a protocol in which participants receive 100 opportunities per day to tact environmental stimuli; this intervention is in addition to the standard instruction that the student receives in the classroom and is typically implemented for participants that do not recruit attention through tacts or wh-questions. Empirical research in VBDT has demonstrated that the implementation of ITI leads to dramatic increases in pure mands and tacts (Pistoljevic & Greer, 2006), increased audience accurate tacts/decreased disapprovals (Schauffler & Greer, 2006), and conditioned reinforcement for approvals and social praise (Schmelzkopf, 2010). Also, Pistoljevic (2008) and Greer and Du (2010), demonstrated ITI as another means through which BiN may be induced.

The auditory match-to-sample protocol is an intervention that teaches individuals to discriminate auditory stimuli in their environment. Empirical research has demonstrated that after mastering the match-to-sample procedure participants often show increases in full and partial echoics (Brown, 2005; Choi, Greer, & Keohane, 2015; Du, Speckman, Medina, & Cole-Hatchard, 2017; Speckman, Park, & Greer, 2007). However, Speckman et al. (2007) and Choi (2012) have also demonstrated the auditory match-to-sample protocol, as another procedure that may induce BiN following the naming experience.

The Source of Reinforcement for Bidirectional Naming

Empirical research on BiN demonstrates three procedures that have repetitively proven effective in the acquisition of the developmental cusp; they are Multiple Exemplar Instruction (MEI) (Greer et al., 2007; Fiorile & Greer, 2007), Intensive Tact Instruction (ITI) (Greer & Du, 2010; Pistoljevic, 2008), and conditioned reinforcement for spoken and visual stimuli (Lo, 2016; Longano & Greer, 2015). Being that each of these interventions provides a history of reinforcement for attending to visual and auditory stimuli, proponents of VBDT believe one probable source of reinforcement for BiN is conditioned reinforcement for observing responses (i.e., voices and attention to two-dimensional and three-dimensional stimuli). Thus, MEI and ITI could be different avenues through which these conditioning experiences take place (Longano & Greer, 2015).

Conditioned reinforcement for observing responses. Longano and Greer (2015) demonstrated the importance of the echoic response as a source of reinforcement for the demonstration of BiN. The findings from this study show that listener and speaker repertoires for BiN only join when visual and auditory stimuli reinforce observing responses of joint attention (i.e., listening to and looking at the stimulus simultaneously). Thus, current empirical evidence from VBDT has suggested rather than reinforcement given from the approval of the caregiver, as described in Horne and Lowe's (1996) naming loop, the source of reinforcement for the initial development of BiN appears to be conditioned reinforcement for observing responses. Moreover, they believe that emulative responses are not solely reinforced by the caregiver's praise, but also through instances of stimulus-stimulus pairing for observation and production responses. Thus, Longano and Greer helped provide an answer to the question of the source of BiN as multiple conditioned reinforcers for observing responses. They concluded that "both visual and auditory stimuli need to have reinforcing properties and reinforce the separate observing responses simultaneously in order for echoic behavior to join listener and speaker repertoires and induce Naming" (p. 100). Therefore, while the data from these experiments support Horne and Lowe's theory that echoic behavior plays a vital role in the joining of listener and speaker responses, their findings also support their hypothesis that echoic behavior can evoke the induction of BiN, after visual and auditory stimuli serve as reinforcers for looking and listening.

Also, Lo (2016) showed a functional relation between the repeated probe experience and the acquisition of conditioned reinforcement for observing auditory speech and non-speech stimuli; this later resulted in the participants' acquisition of novel listener and speaker responses during BiN probes. These data further demonstrated conditioned reinforcement for observing responses as a source of reinforcement for BiN, because the conditioning process of repeated probes induced the stimuli's control over the participants' observing responses while also selecting out the participants' attention during the naming experience; this led to the incidental acquisition of listener and speaker responses. All of these data demonstrated that the establishment of BiN is the function of establishing new reinforcers that subsequently changes how the individual learns. Through further empirical research, VBDT has found additional extensions of BiN and the naming experience, which demonstrate other behaviors and repertoires that are connected to BiN.

Extensions of the Bidirectional Naming Cusp

Bidirectional naming and conditioned seeing. Skinner initially proposed the idea of conditioned seeing as seeing or hearing stimuli that are absent from the current physical environment but are evidently related to the stimuli (Skinner, 1953). This behavior is based on the pattern of conditioned reflex, and thus is a result of previous pairings with stimuli that are currently present in the environment. An example may be pairing the sound of a bell with the presentation of dinner; after these two stimuli have been paired, the presentation of the bell may cause one to "see" or imagine dinner without dinner being present (Skinner, 1957). Shanman (2013) measured the correlation between components of BiN and conditioned seeing through pictures drawn by the participant. The findings demonstrated a positive correlation between these two variables and called for further research on measures that more accurately show the participants' demonstration of conditioned seeing.

Bidirectional naming with actions. Cahill and Greer (2014) also identified a separate kind of BiN, involving additional exposures that provide supplemental stimulus control; Cahill and Greer propose this repertoire might be separate from the joining of listener and speaker responses in traditional BiN. In the first experiment, the name of a visual stimulus was simultaneously presented with an action; data from probe sessions showed that the participants consistently demonstrated the action for the stimuli but did not acquire the name. In the second experiment, a comparative analysis was conducted between the visual stimuli presented with and without a gross motor movement; findings from the research demonstrated that the presentation of an action impeded the participants' acquisition of the auditory name for the stimulus. In the third experiment, a multiple exemplar intervention was applied for participants that demonstrated listener responses when the actions were simultaneously presented. The data from this experiment showed that the participants acquired listener, speaker, and action responses during novel probes, and thus suggested that individuals can acquire multiple responses, from one language exposure, when they have specific learning histories.

Bidirectional naming by exclusion. BiN by exclusion is another type of Naming in which an individual identifies the name for novel stimuli, when all other present stimuli are known (Greer & Du, 2015); the development of this cusp signifies the addition of new stimulus control occurring through naming experiences. Greer and Du (2015) tested a total of 39 preschool students for BiN and BiN by exclusion; the data demonstrated that only five of the 39 participants with BiN demonstrated BiN by exclusion, which suggested that other experiences are necessary for these two BiN cusps to join. Participants were then randomly assigned to an experimental group or control group, in which the experimental group received MEI while the control group received the school's typical curriculum. The MEI presented to the experimental group involved the rotation of point, tact, and intraverbal tact responses under exclusion conditions. For the point response, the participant was expected to discriminate between the exemplars to identify the unknown stimulus. For the tact and intraverbal tact response, the participant was expected to name the given stimulus. The data from their experiment demonstrated that one participant from the control group acquired BiN by exclusion, and all eight participants that received the MEI protocol acquired BiN by exclusion; these data suggest a functional relation between the MEI protocol and the participants' correct listener and speaker responses for BiN by exclusion.

Bidirectional naming in bilingual and monolingual individuals. Initially, research on the establishment of BiN was conducted with monolingual individuals, in their primary language. In 2015, Mosca filled this gap by examining the incidental language acquisition of monolingual and bilingual children to determine whether BiN was a language-specific capability. In three experiments, Mosca (2015) assessed for the presence of BiN, in both English and Swedish, to examine if the individual's instructional history altered their demonstration of BiN. In Experiment I, experimenters assessed the presence of BiN in both Swedish and English for bilingual preschool students, and the data showed that the participants demonstrated the same degree of BiN in both languages. That is if the participant demonstrated BiN in one language it was also present in the other language; the same was shown for UniN. The sum of data from these experiments demonstrated equivalent degrees of UniN in both Swedish and English (i.e., a balanced component of the Naming repertoire was demonstrated if the participant demonstrated UniN or BiN across both languages), while speaker responses were variable and demonstrated no consistency across both languages. Therefore, the findings suggest that bilingual participants incidentally learn in both languages using the same kind of naming experience, but monolingual adults and children understand (i.e., respond as a listener) in their non-primary language before they demonstrate production repertoires.

Cao (2016) analyzed the effect of the emergence of BiN, in a second language, on monolingual English-speaking preschool children who demonstrated BiN, in their primary language. The first experiment consisted of 32 monolingual English-speaking children, randomly assigned to two groups; one group completed echoic probes in Chinese phonemes with English approximation (i.e., Chinese phonemes that sound similar to English), and the second group completed the same echoic probes with distinctive Chinese phonemes. Data from the first experiment demonstrated that participants who received Chinese phonemes with English approximations outperformed their counterpart participants, who received distinctive Chinese phonemes; these data suggested the distinctiveness of the phonemes as a variable that affected the number of correct echoic responses emitted by the participants as a speaker. The second experiment tested the effects of echoic training on the emergence of BiN in Chinese; during this intervention, the participants were taught to echo target consonant-vowel combinations independently without an echoic model. Following the implementation of the echoic training five out of six participants demonstrated BiN in Chinese. Data from both of these experiments demonstrated, as consistent with Mosca (2015), that BiN is a language-specific developmental cups for monolingual English-speakers.

Bidirectional naming with auditory stimuli. Lo (2016) continued research on the different demonstrations of BiN, by testing the presence of the cusp when Naming experiences were presented with other auditory experiences. In these experiments, following three additional rounds of repeated probes (i.e., that is in addition to the two given for baseline measures) participants demonstrated criterion level responding for speaker responses with visual stimuli as well as BiN with auditory non-speech stimuli. The data from the first experiment suggested that the process of repeated probes functioned as a means through which the sensory stimuli were conditioned as a reinforcer; after the stimuli were conditioned, participants emitted more accurate responses during BiN probes. In Experiment II, experimenters tested the effects of repeated probe experiences on the establishment of reinforcement for auditory stimuli; the findings from this experiment suggested that the repeated probe intervention did function as a conditioning procedure and resulted in the acquisition of transformation of stimulus function across listener and speaker responses for some participants. The findings from Experiment III were consistent with Experiment II, and also demonstrated increases in BiN with contrived auditory non-speech stimuli.

Bidirectional naming across the senses. Frias (2017) analyzed the way stimulus relations accrue while learning the name of stimuli, in preschool students with and without disabilities. In Experiment I, participants received stimulus-stimulus pairings with one modality and the name of the stimulus; these data demonstrated that five of the six participants demonstrated BiN with visual stimuli and at least one other modality. In the second experiment, stimulus-stimulus pairings were repeated across visual, auditory, tactile, and olfactory stimuli, while simultaneously being presented with the name for each modality set. Findings from this experiment revealed that some of the participants demonstrated a transformation of stimulus control from visual to auditory stimuli so that auditory stimuli had the same stimulus function. The overall findings of these experiments, along with the findings in Lo (2015), suggest that stimulus-stimulus pairings may provide the instructional history necessary for the development of BiN across multiple stimulus modalities.

Stimulus Equivalence

BiN describes a verbal developmental cusp that is characterized by the incidental acquisition of language after exposure to a naming experience. Initially, untaught relations were first demonstrated through Sidman's (2000) description of stimulus equivalence, which described the emergent behaviors as bi-directional relations. In its fundamental form, stimulus equivalence describes the acquisition of untrained stimulus-stimulus relations, after acquiring a set of related conditional discriminations (Hayes & Barnes-Holmes, 2004). This phenomenon was tested in a demonstrative study with teenage boys, described as intellectually delayed (Sidman, 1971). At the onset of the study, the participants demonstrated match responses for the spoken word for car and a picture of the car and were later taught to match the spoken word for car with the textual print "car". Following this training, Sidman assessed the students' comprehension of the textual stimuli, by conducting a probe in which the participants were required to match the printed word for car to a picture of a car, and a picture of a car to the printed word for car. The results demonstrated that the participants matched these stimuli, without direct training of the stimulus relations, and thus Sidman concluded that the participants demonstrated stimulus equivalence.

Following their research on match-to-sample procedures, and the emergence of stimulus relations, Sidman and Tailby (1982) borrowed from the idea of mathematical set theory (Minister, Jones, Eliffe, & Muthukumaraswamy, 2006) to postulate the properties of stimulus equivalence as: (1) reflexivity, (2) symmetry, and (3) transivity (Hayes & Barnes-Holmes, 2004). Reflexivity describes when a stimulus conditionally relates to itself (i.e., if A then A). Symmetry describes when relations between stimuli are reversible, and thus training would teach “if A then B”, and the individual would also be able to derive “if B then A”. Transitivity describes when two separately taught relations (i.e., if A = B and B = C), results in the emergence of a new untaught relation between two stimuli (i.e., then A = C).

Sidman’s description of stimulus equivalence was the basis of emergent language or language that was acquired without any direct instruction. Through this description, Sidman argued that stimulus equivalence was a linguistic prerequisite (Horne & Lowe, 1996; Sidman, 1986), and therefore was a determining variable "both for what people say and for their reactions to what other people say. In particular, the existence of equivalence relations can account for such utterances as ‘meaning', ‘symbol', ‘referent', and ‘rule-governed' " (Sidman, 1992, p. 20).

The Application of Bidirectional Naming to Stimulus Equivalence

In their initial description of BiN, Horne and Lowe (1996) believed that stimulus equivalence could be established or strengthened through the naming relations present during match-to-sample tests of equivalence. Also, they contended that intraverbal naming may be a way through which organisms establish stimulus classes from stimuli that have been related. For example, if being trained with A1→ B1 and A1 → C1 relations, the participant's constant echoing of the stimuli names during procedures may essentially train both intraverbal name pairs under one common name. "In this case the child continues to name the correct sample-comparison task (i.e., enables the child to ‘remember' what goes with what) and is thus reinforced through the experimental contingencies" (Horne & Lowe, 1996, p. 220). Therefore, through these findings Horne and Lowe (1996) posit that stimulus equivalence, as measured through match-to-sample tests, can be established through several avenues, some being (1) common naming, (2) intraverbal naming, and (3) more complex verbal rules. However, being that all of these methods use different behavioral processes, Horne and Lowe also believed they have different behavioral outcomes. Thus, because there are different avenues in which an individual can establish equivalent relations, Horne and Lowe agree that a common term for the phenomenon is needed. At the same time, they believe that our focus on stimulus equivalence is misguided, and the phenomenon may be the outcome of a more important verbal repertoire. Thus, the theorists stated:

> What has not until now been appreciated, however, is that success on stimulus equivalence tests may be secondary and indirect outcomes of more varied and fundamental verbal processes. Most researchers in this area, although ostensibly

investigating the ‘new' phenomenon of stimulus equivalence, may, in fact, have been studying naming and other forms of verbal behaviors but under a different name (p. 237)

Being that stimulus equivalence research often did not measure naming relation behaviors, Horne and Lowe (1996) contend we have overlooked the basis of the connection to study a byproduct of the verbal phenomenon. In that way, the authors wonder if the theory of stimulus equivalence is necessary.

Eikeseth and Smith's (1992) research provided further empirical research for Horne and Lowe's (1996) claim that naming is an essential determinant in the performance of stimulus equivalence. Data from the study demonstrated that naming might help students with the establishment of stimulus classes, thereby making naming a pre-requisite repertoire. The first phase consisted of the implementation of match-to-sample training and assessed the establishment of stimulus classes. The second, third, and fourth phases of the experiment also assessed the establishment of stimulus classes, with the addition of a tact procedure in which children were taught the name for the stimuli. The participants demonstrated higher match responses in phases that also had the naming procedure. Eikeseth and Smith (1992) concluded, “naming may remediate failures to develop untrained conditional relations, some of which are indicative of stimulus equivalence” (p. 123). These data also support Sidman’s (1994) idea that naming, and other procedures that require the participant to classify, categorize, or partition stimuli, also involves equivalence relations.

Furthermore, research analyzing naming and stimulus equivalence has also demonstrated that all participants assigned names for each stimulus, and coincidentally all of the children that demonstrated stimulus equivalence also intraverbally named the correct sample-comparison pairs (Dugdale & Lowe, 1990; Lowe & Beasty, 1987). Thus, demonstrating that during match-to-sample procedures the participant is likely naming the stimulus, and through reinforcement of the relational response, the names are also consequated. "As the child learns the AB relation, she will thus increasingly tend to name successful sequences of responding to stimuli" (Horne & Lowe, 1996, p. 219).

However, this idea was contended by Stromer and Mackay (1996) who raised questions against some of the claims made by Horne and Lowe (1996). More specifically, Stromer and Mackay question Horne and Lowe's claim that:

> If it could be shown that any nonverbal human (e.g., young infant) or other human subjects who did not name stimuli or use verbal rules during a study could pass Sidman's test, then this alone would show that verbal behavior was not necessary for success (p. 331-332).

While Stromer and Mackay (1996) suggested that there isn't enough empirical evidence to make any significant claims regarding stimulus equivalence in nonhumans, they also contend that this claim may have been debunked by research conducted with individuals demonstrating limited verbal capabilities. More specifically, Sidman et al., (1986) and Green (1990) are all studies that have used individuals diagnosed with cognitive delays, most of whom passed equivalence tests without passing referent naming tests. Also, Saunders and Green (1992) contend that:

> (1) organisms with limited verbal repertoires have demonstrated equivalence classes for abstract visual stimuli, (2) subjects that are classified with significant cognitive delays demonstrate auditory-visual equivalence classes, and (3)

> organisms with severe language and learning deficits can demonstrate the development of equivalence relations, but they rarely engage in this naming unless required to do so by contingencies (p. 313)

Stromer, Mackay, and Remington (1996) also contribute to this debate by bringing to question some of what they believe are methodological faults in studies like Devany, Hayes, and Nelson (1986) and Eikeseth and Smith (1992) which have been referenced as primary articles demonstrating the significance of naming in stimulus equivalence. Ultimately, Saunders and Green concluded that rather than naming being a pre-requisite or fundamental process of stimulus equivalence, naming should be referred to as a separate capability initiated by contingencies that induce the pre-requisites needed for equivalence relations. Stromer et al. (1996) conclude that Horne and Lowe's (1996) article has further demonstrated the need for basic and applied research that analyze the conditions, under which, participants establish arbitrary equivalence classes.

New empirical research on the establishment of untaught relations. Following Saunders and Green's comments, there has been more empirical research on the establishment of untaught stimulus relations which have contended that while stimulus equivalence may be induced in non-humans and individuals with low verbal competence, the repertoire is in some way affected by an individuals' verbal competence.

Lee, Miguel, Darcey, and Jennings (2015) tested the effects of a listener training on categorization and speaker behavior of children with autism. Their findings demonstrated that two participants that showed naming, as measured through a standardized language assessment, emitted categorization and tact responses following listener training; however, the remaining two participants that demonstrated deficits in the naming repertoire did not emit these responses until tact training was implemented. Thus, these data and other replications of this research on stimulus categorization and naming, has suggested that a child's demonstration of untrained relations may be dependent on their overall naming repertoires (Kobari-Wright & Miguel, 2014; Miguel & Kobari-Wright, 2013; Miguel et al., 2008).

New Conceptual Research on the Establishment of Untaught Relations

In expanding the research on how stimulus equivalence is informed by an individual's naming repertoire, new conceptual research like Relational Frame Theory (RFT) has emerged to extend Sidman's theory greatly. While Sidman’s relations of reflexivity, symmetry, and transivity changed the way prior research looked at the acquisition of untaught relations, it only dealt with relations that were equivalent and thus was the tip of the iceberg for this research. RFT dramatically expands on stimulus equivalence by including more kinds of contextual control, beyond sameness; this expansion allows for the analysis of other relational responses outside of symmetry. “While much of the work on derived stimulus relations has focused on equivalence, if relating itself can be learned and brought under contextual control, a wide variety of relational responses seem possible” (Hayes et al., 2001, p.29). In addition, Sidman initially described stimulus equivalence as a biological phenomenon that children developed due to phylogenic sources like psychological processes. Later RFT would reveal the true source of these relations were established through experiences with the environment (i.e., ontogenetic).

Relational Frame Theory

Relational Frame Theory (RFT) (Hayes et al., 2001) is a behavior analytic account of language and cognition, which is fundamentally similar to Skinner's account of language in its focus on the function of language rather than viewing language as a product (Gross & Fox, 2009; Hayes et al., 2001), but also fundamentally different in its definition and criteria of those verbal events and activities. RFT postulates that humans develop language through their establishment of derived stimulus relations; more specifically, the relations they develop amount to stimulus events without direct training or instruction (Gross & Fox, 2009). This kind of responding is easily recognizable when discussing relational responding that is based on the formal characteristics of stimuli (i.e., when you can relate two stimuli due to similarities or differences among physical dimensions). However, because this responding is entirely bound by the formal properties of the events, it cannot be considered derived relational responding. Derived relational responding is conveyed when an "organism could learn to respond relationally to objects where the relation is defined not by the physical properties of the object but by some other feature of the situation" (Hayes et al., 2001, p. 25). Thus, relational responding is transformed into an overarching arbitrarily applicable operant when a relational response is controlled by contextual cues rather than the physical dimensions of the stimuli. Therefore, arbitrary relations (i.e., derived relations) refers to the idea that in some context the responses comes under the control of contextual cues that can be changed on the basis of social conditions (Hayes et al., 2001).

Properties of Relational Frames

To account for other relational responses that are not symmetrical, RFT has adopted more general terminology and analyzes multiple responses that occur from three qualities of derived relations: mutual entailment, combinatorial entailment, and transformation of stimulus function. Mutual entailment describes an organism deriving a bidirectional relation, after being taught a unidirectional relation. More specifically, in this phenomenon after being taught A is relational to B, the organism would derive that B is also relational to A. Thus, while the first relation is taught directly, the second relation is entailed, and thus relations of this type would be mutually entailed. Mutually entailed responses may vary and can also involve other relations like more than/less than. Therefore, RFT's use of the term mutual entailment builds on Sidman's idea of symmetry, as it helps to encompass bidirectional relational responses that are not only symmetrical (Hayes et al., 2001).

Combinatorial entailment describes the relationship that emerges between two episodes of mutual entailment. That is, after being taught the relation between three stimuli (i.e., A → B and A → C) the organism demonstrates the formation of an untaught relation between the latter two stimuli, (i.e., then B → C). Combinatorial entailment expands Sidman's idea of equivalence by encompassing more relations that may vary (e.g., stronger/weaker) outside of equivalent relations. Hayes et al. (2001) also contended that this new and more generic term is needed because it "eliminates some of the unfortunate confusion in the equivalence literature caused by viewing transitivity in a linear fashion" (p. 30).

Transformation of stimulus functions occurs when the function of a stimulus is transferred to another stimulus based on a latent derived relation. That is if an individual is directly taught to relate B as the same as A, and then A is given a conditioned reinforcing function (e.g., pairing A with receiving another reinforcer like points, tokens, or food), B might take on the same reinforcing effect without direct training. Transformation of stimulus function has been demonstrated with conditioned reinforcing functions (Hayes, Kohlenberg, & Hayes, 1991), discriminative functions (Hayes, Brownstein, Devany, Kohlenberg, & Shelby, 1987), conditioned emotional responses (Dougher, Augustson, Markham, Greenway, & Wulfert, 1994), extinction functions (Dougher et al., 1994), and many other functions (Hayes et al., 2001). However, Hayes et al. (2001) states that within transformation of stimulus functions the transformation must be under contextual control, because "a given stimuli always has many functions, and if all functions of one stimulus transferred to another and vice versa, there would no longer be two separate psychological stimuli" (p. 32).

Types of Relational Frames

Within each of the three properties mentioned, there are various units of relational frames. Hayes et al. (2001) defined a relational frame as a class of arbitrarily applicable relational responses that demonstrates contextually controlled qualities of mutual entailment, combinatorial entailment, and transformation of stimulus functions. Proponents of RFT state that while relational frames are both outcomes and processes, contextually controlled qualities are solely outcomes because they define relational frames rather than explaining them. Hayes et al. stated:

> The process is the history that gives rise to a relational operant that is under a particular kind of contextual control. Stated another way, the process involved is contingencies of reinforcement, but unlike Sidman (2000) relational responding is not a previously unknown secondary effect of such contingencies, it is the target of them. (p. 34)

Furthermore, relational frames are contextually controlled because their occurrence depends on the presence of contextual cues, which permits the individual to make arbitrary responses that are not based on the physical properties of the stimuli.

While RFT recognizes that there are many relational frames, some of the more common relational frames are coordination, opposition, distinction, comparison, hierarchical relations, temporal relations, spatial relations, conditionality/causality, and deictic relations. Frames of coordination establish an equivalence class and describe a relation of sameness or similarity (Hayes et al., 2001). Naming (i.e., learning the name for a stimulus) is a primary example of a frame of coordination, in which the individual relates the name of an object (e.g., stimulus A) with the visual representation of the object (e.g., stimulus B). Proponents of RFT believe that frames of coordination are most likely the first to be abstracted because this kind of word learning represents the bulk of early language training (Hayes et al., 2001). Frames of opposition describe stimuli that differ in opposite directions, on the same dimension, according to a point of reference (Hayes et al., 2001). An example of this could be thinking about temperature and the idea of cold and hot. Cold and hot are both along the dimension of temperature and differ in opposite directions from the point of reference, which would be the typical temperature of the human body. Frames of distinction involve a response to an event based on its difference from another event; however, unlike a frame of opposition, the nature of the response is unspecified (Hayes et al., 2011). For example, if an individual were told, "This is not warm water", the listener would still not know whether the water was cold or hot. A frame of comparison "is involved whenever one event is responded to in terms of a quantitative relation along a specified dimension with another event" (Hayes et al., 2001, p. 36); specific subtypes of this frame are bigger/smaller, faster/slower, or better/worse. Hierarchical relations are also relational patterns as demonstrated in the frame of comparison; however, the relations are not solely qualitative, and thus the relations are more specific without quantification. Hayes et al. (2001), provides family relations as an example of hierarchical relations:

> If I tell you that Bob is the father of Dave and Barb, you can derive that Dave and Barb are siblings (a hierarchical frame). If however, I tell you that Bob is taller than both Dave and Barb you cannot derive a relation of relative tallness between the latter two individuals (a frame of comparison). (p. 37)

Temporal frames are another relation that shares the pattern of a comparative frame; however, they share a more exclusive nature of physical dimensions because the primary dimension of time is change (e.g., before/after) (Hayes et al., 2001). Thus, temporal relations are inherently more abstract because relations of time are often more arbitrary than relations of size. Spatial frames detail relational frames, which describe object arrangements relative to each other (e.g., in/out, back/front, under/on). Conditionality and causality also involve hierarchical and comparative relations and detail frames where one event is said to cause another event based on features like sequence, continuity, and manipulability (Hayes et al., 2001). Finally, dietic relations are frames that stem from the speaker's perspective (e.g., left/right or you/I).

Relational Frames as a Generalized Operant

Operant behavior is a response that is primarily determined based on the history of consequences that have followed the behavior. Different from respondent behavior, "operant behavior is selected, shaped, and maintained by the consequences that have followed it in the past" (Cooper, Heron, & Heward, 2007, p. 31). While operant behavior is defined by its effect on the environment, the topography of the response in an operant class may vary. Opening a door, for example, has several responses (e.g., pushing with your palms, kicking with your foot, bumping with your hip), which would, in turn, produce the same effect on the environment (i.e., an open door). A generalized operant is an operant in which the physical form of the behavior may vary greatly, while still having the same effect in a given context. Generalized imitation, demonstrates a generalized operant, because while the antecedent (i.e., "do this") and the function of the behavior (i.e., gaining reinforcement through praise or through point to point correspondence with the initial behavior) are consistent, the behavior that is performed can vary considerably (e.g., clapping your hands, doing a handstand, or rolling on the floor).

Proponents of RFT believe that relational frames are an analytical unit that constitutes a three-term generalized operant, which is comprised of (1) a history of differential reinforcement, (2) a relational response, and (3) contextual cues (Healy, Barnes-Holmes, & Smeets, 2000). Research in RFT has demonstrated that relations may be manipulated through differential feedback (Healy, Barnes, & Smeets, 1998; Healy et al., 2000), therefore demonstrating that derived stimulus relations "come under antecedent and consequential control and can be modified into multiple forms" (Berens & Hayes, 2007, p. 63). Since its establishment, there have been multiple empirical studies that have demonstrated derived relations in infants (Lipkens, Hayes, & Hayes, 1993; Luciano, Becerra, & Valverde, 2007), increases in children's intelligence quotient upon establishment of derived relations (Cassidy & Roche, 2011; Vizcaino-Torres, Ruiz, Luciano, Lopez-Lopez, Rubio, & Gil, 2015), the establishment of derived relations for children with severe cognitive and language delays (Howarth, Dudek, & Greer, 2015), and multiple studies which demonstrate match-to-sample procedures to establish relational frames.

Derived Relations as a Dependent Variable

Within RFT, there are two fundamental assumptions on teaching derived relations. The first is that verbal relational skills are the foundation for a variety of other cognitive abilities that foreshadow academic achievement (Barnes-Holmes et al., 2001). The second is that multiple exemplar training is the primary intervention through which the aforementioned cognitive abilities are developed. Throughout the research in RFT, Multiple Exemplar Training (MET) is often the intervention applied when participants fail derived relation probes following SEI, and thus a majority of research employs MET or a match-to-sample procedure when training relational frames. MET has been demonstrated effective in inducing symmetrical relations (Barnes-Holmes, Barnes-Holmes, & Smeets, 2001; Rosales, Rehfeldt, & Lovett, 2011), establishing derived equivalence in infants (Luciano et al., 2007), establishing the transformation of mand function (Murphy, Barnes-Holmes, & Barnes-Holmes, 2003), and establishing multiple derived relations (Beers, 2013). While there has been some research in alternative procedures to teach derived relations (Dymond & Whelan, 2010) statistical analyses showed these interventions did not significantly demonstrate differences and involved the same number of trials needed for the participant to demonstrate criterion, as MTS procedures.

Rationale for Study

In the literature on the acquisition of language there remain gaps between current updated literature on BiN and its possible correlation to derived relations and relational response repertoires. The first gap that remains is that a majority of this research has discussed the naming relation as is described in Horne and Lowe (1996). However, very little of this research relates derived relational responses to new research on BiN as a verbal developmental cusp. That is, in much of the research defined above the naming they refer to is learning the name for a stimulus class (i.e., category), rather than the developmental cusp that describes incidental language acquisition. However, more recent research on BiN has demonstrated the presence of the developmental cusp as the stage in which children begin to acquire language incidentally, from different contingencies, and through different instruction (Greer, Corwin & Buttigieg, 2011; Hranchuk, 2016). More specifically, this research has also demonstrated that the establishment of BiN is a function of the establishment of new motivating operations and reinforcers. Thus, further research should be conducted on BiN and derived relations to see if the establishment of these reinforcers allows the establishment of new relational frames or whether derived relational responses create the necessary instructional history to acquire language incidentally.

Research Questions for Experiment I

1. Is there a relation between the degree of BiN and the production of derived relations and non-arbitrary relations?
    a. Is there a relation between the participants' degrees of BiN with familiar stimuli and the establishment of relational responses?
    b. Is there a relation between the participants' degree of BiN with unfamiliar stimuli and the establishment of derived relations?
2. Is there a relation between the property of derived relational responses established (i.e., mutual entailment or combinatorial entailment), and the participants' degree of BiN with familiar and unfamiliar stimuli?
3. Is there a difference between the emission of intraverbal tact and intraverbal responses in the establishment of stimulus relations?

CHAPTER II

EXPERIMENT I

Method

Participants

Participants were 31 preschool students whose ages ranged from 2.9 to 5.11 at the onset of the study ($M = 3.94$, $SD = .57$). Of the 31 participants, 23 were male, 26 were classified as a preschooler with a disability or had a diagnosis, and 10 were English Language Learners. An English Language Learner was defined as a student who spoke or was spoken to, in any language other than English in the home setting. Diagnoses were consistent with what was reported on each participant's Individualized Educational Plan (IEP) at the onset of the study. All students with an IEP, without a diagnosis confirmed by a Committee on Preschool Special Education (CPSE) meeting or a neurological report, were classified as a preschooler with a disability, as per the New York State Special Education Regulations. Regarding race/ethnicity, 45% of participants were Hispanic or Latino, 41% were White, 6% were African American, and 6% were Asian.

Table 1

Description of Participants for Experiment I

Variable	*N*	Percent
Gender	M = 23 F = 8	M = 74% F = 25%
Classification/Diagnosis	Autism = 2 PwD = 24 None = 5	A = 6% PwD = 77% N = 16%
English Language Learner	10	32%
Neighborhood Poverty Level	0-4.9% = 5 5-9.9% = 9 10-19.9% = 10 ≥ 20% = 7	0-4.9% = 16% 5-9.9% = 29% 10-19.9% = 32% ≥ 20% = 22%
Boehm Percentile Rank	Rank 1- 19 Rank 2- 4 Rank 3- 8	Rank 1- 61% Rank 2- 12% Rank 3- 25%

Note. Neighborhood Poverty Level was defined as the percentage of people residing in the neighborhood that were living below the national poverty level according to their household size. Neighborhood Poverty Level was determined by data sourced from the United States Census Bureau's 2012-2016 American Community Survey. Preschooler with a disability (PwD) was an educational classification assigned to students without a medical or psychological diagnosis. Participants' Boehm Percentile Rank was calculated based on their raw score and age at the time the test was administered. Rank 1 constituted students that demonstrated scores in the highest range of their age group, Rank 2 constituted students that demonstrated scores in the mid-range of their age group, and Rank 3 constituted students that demonstrated scores in the lowest range of their age group. See Table 2 for these cut-off scores.

Table 2

Boehm Performance Range by Age

Performance Range	3.0 to 3.5 Raw Score	3.6-3.11 Raw Score	4.0-4.5 Raw Score	4.6-4.11 Raw Score	5.0-5.5 Raw Score	5.6-5.11 Raw Score
1	33-52	37-52	34-52	39-52	44-52	46-52
2	26-32	28-36	28-33	34-38	39-43	42-45
3	≤ 25	≤ 27	≤ 27	≤ 33	≤ 38	≤ 41

Note. Performance range is a measure of each participant's raw score as compared to their age-level peers. Range 1 represents the upper third range, meaning the child demonstrated most of the basic concepts. Range 2 represents the middle third range, meaning the child demonstrated many basic concepts with deficits in understanding fundamental concepts. Range 3 represents the lower third range, meaning that the child demonstrated a deficient knowledge of basic concepts.

Table 3

Race/Ethnicities of Participants for Experiment I

Race/Ethnicity	*N*	Percent
White	13	41%
African American	2	6%
Latino/Hispanic	14	45%
Asian	2	6%

The participants were recruited from a publicly funded preschool in a Northeastern suburb outside of a metropolitan area. The school served a diverse population of students with and without disabilities, and this is reflected in the participants selected for Experiment I and II. See Table 1 and 3 for a description of the race/ethnicity and socioeconomic status of the participant sample. The school followed the Comprehensive Application of Behavior Analysis to School (CABAS ®) education model. This model applies empirical methods of pedagogy, curricula, and classroom management; the primary curriculum used for all students in the school was the CABAS ® *International Curriculum and Inventory of Repertoires for Children from Preschool through Kindergarten* (C-PIRK) (Greer & McCorkle, 2009). Students were assessed using the *Verbal Behavior Development Assessment-R* (VBDA) (Greer, 2010) and the *Boehm Test of Basic Concepts- 3 Preschool* (Boehm, 2001). The VBDA-R measures language development by assessing cusps and capabilities across repertoires, including listening, speaking, writing, editing, algorithmic, and social repertoires; based on the VBDA-R all of the participant were described as functioning on a listener/speaker level of verbal behavior. Teachers and professionals that administered the C-PIRK and VBDA-R were calibrated and regularly observed for fidelity and accuracy of their measurement of the students' responses. The Boehm is a criterion-referenced measure that evaluates basic positional concepts of young children; the concepts assessed, measured the child's demonstration of relational decisions about people, things, and events. The Boehm was utilized because it is a listener-based assessment of relational concepts; thus, the Boehm provided a basis of the participants' demonstration of basic concepts as well as another measure of relational concepts that can be used to ascertain the relation between BiN and both arbitrary and non-arbitrary relations.

Inclusion criteria. Since all instruction and probes conducted involved the student following teacher directions, attending to vocal directions, and attending to assessment and training stimuli, students were selected based on their demonstration of necessary developmental cusps and verbal repertoires. All students chosen as participants were required to demonstrate all of the following pre-requisite repertoires: (1) teacher presence results in instructional control, (2) conditioned reinforcement for voices, (3) conditioned reinforcement for 3D and 2D stimuli, (6) Generalized imitation, and (7) Basic listener literacy. See Table 4 for an in-depth definition of these behavioral cusps as described through the Verbal Behavior Development Theory (VBDT).

Table 4

Definitions of Prerequisite Behavioral Cusps and Repertoires

Behavioral Cusp	Definition
Teacher Presence Results in Instructional Control	When the student is in the presence of a teacher they comply with all directions given
Conditioned Reinforcement for Voices	Individual demonstrates reinforcement for attending to voices in their environment
Conditioned Reinforcement for 3D and 2D stimuli	Individual demonstrates reinforcement for attending to 2D and 3D stimuli
Generalized Imitation	Individual demonstrates imitation of novel gross motor movements following a visual model
Basic Listener Literacy	Individual demonstrates discrimination of vocal instructions presented by the teacher, and responds to simple 1-step directions at an appropriate fluency

Participant grouping. The participants' inclusion in each analysis was based on the derived relation training that they completed. Group A consisted of participants that completed all three training phases, and thus these participants were included in analyses on arbitrary and non-arbitrary derived relations. Group B consisted of participants that completed training phase 1 and 2; these participants were included in analyses of non-arbitrary relations. Table 5 describes the differences in these participants' verbal repertoires as measured by their Boehm scores and their demonstration of BiN.

Table 5

Description of Participants Based on Analysis Groups

	Group A			Group B			Participant Sample		
	Range	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*
Degree of BiN	17.5-100%	54.37	19.24	17.5-100%	56.30	19.95	2.5-100%	46.93	24.48
Boehm Score	26-98%	74.37	19.84	26-98%	73.43	20.02	12-100%	71.29	22.98

Note. Group A (n = 16), Group B (n = 23), Participant sample (N = 31). The participants' Boehm score was a measure of the percentage of correct responses emitted on the assessment.

Setting and Materials

All of the instructional and assessment sessions took place inside of the students' classroom, in another classroom/ room where other students were present and engaged in other instructional tasks, or in an empty office space. The experimenter minimized distractions by seating the participant away from high traffic areas and removing any known visual distractors. During each instructional and probe session, participants were seated in a chair across from the experimenter, with a table separating them; the desk used in all intervention and probe sessions was 26" by 20.5" by 29". Materials used were an I-Pad, to display training and assessment stimuli, data sheets, and pens. Table 6 and 7 detail the stimuli used for BiN probes; Table 15 details the stimuli used for derived relation training and assessment.

Table 6

Sets of Unfamiliar Stimuli Used for BiN Probes

	Stimulus Name	Stimulus
Unfamiliar Set 1	Lam	
	Wem	
	Mek	
	Sade	
	Qop	
Unfamiliar Set 2	Tet	
	Beth	
	Yod	
	Ox	
	Haj	

Table 7

Sets of Familiar Stimuli Used for BiN Probes

	Stimuli
Set 1	Collie
	Maltese
	Beagle
	Poodle
	Husky
Set 2	Fig
	Guava
	Basil
	Quince
	Guinep

Dependent Measures

The dependent variables for the study were the degree of BiN for familiar and unfamiliar stimuli, as measured by the number of correct untaught listener and speaker responses following the naming experience, the degree of arbitrary derived relations, as measured by the number of correct untaught listener and speaker responses following training in an A → B relation, and the degree of non-arbitrary relational responses, as measured by the number of correct untaught speaker responses following training in an A → B or A → C relations. The participants' degree of BiN was measured with 20 total responses (i.e., 10 listener responses and 10 speaker responses). The participants' degree of non-arbitrary relational responses was measured with 20 speaker responses for mutually entailed relations. The participants' degree of arbitrary derived relations was measured with 10 listener responses and 28 speaker responses for mutually and combinatorially entailed relations. Criterion for the demonstration of all dependent variables was defined as 80% accuracy in one novel probe; criterion of 80% accuracy was used because this is the criterion that has been replicated through all prior evidenced-based research on BiN. Table 9 shows a description of all relations taught and assessed in phases 1-3.

Table 8

Description of Stimulus Classes for Experiment I

Phase	A Name	B Picture	C Stimulus Class (Phase 3)
1	Insect		Int
	Feline		Ver
2	Mollusk		Int
	Serpent		Ver

Note. All names taught within the experiment were 1-2 syllables. Ver was the experimentally contrived replacement name for vertebrate. Int was the experimentally contrived replacement name for invertebrate.

Table 9

Description of Training and Assessment Sequence for Arbitrary and Non-Arbitrary Relations

Relation	Phase	Trained Relation(s)	Untaught Relation(s) Assessed
Non-Arbitrary	1	A → B A → B	B → A B → A
	2	A → B A → B	B → A B → A
Arbitrary	3	B1 → B2 C → A1A2	C → B B → C B1B2 → C B2 → B1 A → C

Note. The numbers described for arbitrary relations refer to the phase in which the stimulus was trained.

Data Collection

Data assessing for both BiN and derived relations were collected in the same manner for all experiments. During each training session, a correct response was immediately followed by praise and a plus (+) was recorded on the data sheet; correct responses emitted during probe sessions were recorded in the same manner with no reinforcement. During each training session, an incorrect response was immediately followed by the correction procedure, and a minus (-) was recorded on the data sheet; incorrect responses emitted during probe sessions were recorded in the same manner with no correction procedure.

Procedure- Bidirectional Naming

The naming experience. The naming experience consisted of match-to-sample instruction that provided consequences for each learn unit. For each session, the participant received four opportunities to match each of the five stimuli for a total of 20 match responses. Criterion was 90% accuracy in the first session. This naming experience procedure was used for Experiment I and II.

During each session, the experimenter was seated at a table across from the participant, and the experimental stimuli were displayed on an I-Pad. The screen showed one target stimulus on the left and three comparison stimuli on the right. At the start of the learn unit, the experimenter pointed to the target stimulus and named the stimulus (e.g., "This is a collie"), and then presented the antecedent "match _____ with _____" (e.g., "Match collie with collie"). The participant was then expected to point to the target corresponding stimulus. If the participant pointed to the corresponding target exemplar, the experimenter delivered vocal reinforcement and playful physical contact. If the participant pointed to a non-target exemplar or did not respond, the correction procedure was implemented.

Table 10

Description of the Naming Experience

Antecedent	Behavior	Consequence
Experimenter: "This is a poodle. Match poodle with poodle." 	*Correct:* Pointing to the corresponding picture of a poodle	Reinforcement in the form of praise or playful physical contact (i.e., tickles)
	Incorrect: The absence of a response or pointing to a non-exemplar (i.e., a picture of an animal that does not correspond)	The implementation of the correction procedure, which involved the experimenter modeling the correct response then giving the participant a chance to respond independently.

Bidirectional Naming probe. After the naming experience, the experimenters conducted a probe 2 hrs later for the listener and speaker responses of BiN. Probe trials consisted of two opportunities per response type (i.e., listener and speaker) for a total of four opportunities to respond to each 2D stimulus and 20 opportunities for the entire probe session. UniN was demonstrated if the student pointed with 80% accuracy, and BiN was demonstrated if the student pointed and emitted an intraverbal tact with 80% accuracy. During probe trials, no feedback was provided based on the participants' accuracy. This procedure was used for Experiment I and II.

While assessing the listener response, the participant was required to identify a target stimulus within a field of three (e.g., one target stimulus and two non-target exemplars), following the experimenter's antecedent (i.e., "Point to __). The two non-target stimuli were other stimuli which were taught during the naming experience. If the participant pointed to the target stimulus, the response was recorded as correct by marking a plus (+) on the data sheet. If the participant pointed to a non-target exemplar or did not emit a response after 5 s, the response was recorded as incorrect by marking a minus (-) on the data sheet. While assessing the speaker response, the participant was required to emit an intraverbal tact, following the experimenter's presentation of a 2D stimulus and the antecedent (i.e., "What is this?"). If the participant emitted the target tact, the response was recorded as correct by marking a plus (+) on the data sheet. If the participant emitted a non-target tact or did not respond within 5 s of the experimenter presenting the antecedent, the response was recorded as incorrect by marking a minus (-) on the data sheet.

Table 11

Description of Probe Trials for BiN Probes

Antecedent	Behavior	Consequence
Listener:		
Experimenter: "Point to the poodle." 	*Correct:* Pointing to the target exemplar named *Incorrect:* The absence of a response or pointing to a non-exemplar	N/A
Speaker:		
Experimenter: "What is this?" 	*Correct:* Saying the name of the picture presented *Incorrect:* The absence of a response or saying the name of a non-exemplar	N/A

Procedure- Arbitrary and Non-Arbitrary Relational Responses

Listener training (phase 1). Listener training consisted of the participant identifying the target stimuli, with a point response, using SEI. This training phase consisted of two experimentally defined five-member classes (i.e., feline and insect). For each session, the participant received 10 opportunities to point to each stimulus class for a total of 20 massed trials. The criterion for each stimulus class was 90% correct responding for two consecutive sessions or 100% correct responding in one session. All participants were exposed to a minimum of two training phases.

During each session, the participant was seated across from the experimenter with the stimuli (i.e., I Pad) placed on the table in between them. The experimenter presented three stimuli, with one target exemplar and two non-target exemplars. One non-target exemplar was from a different stimulus class, which was targeted in that training phase. The other non-target exemplar was a novel visual stimulus that was not included in either stimulus class. After presenting the stimuli, the experimenter presented the vocal antecedent (e.g., "point to the feline"), and the participant was given 3 s to respond. If the participant pointed to the target exemplar, the response was recorded as correct, and reinforcement was delivered. If the participant pointed to a non-exemplar, the response was recorded as incorrect, and the correction procedure was implemented. During the correction procedure, the experimenter modeled the correct response (i.e., pointed to the target stimulus), and then re-presented the antecedent to give the participant an opportunity to emit the response independently. If the participant continued to emit the incorrect response after the correction procedure, the experimenter delivered the correction a maximum of three times before proceeding to the next learn unit.

Table 12

Description of the Learn Unit for Listener Training Phase 1 and 2

Antecedent	Behavior	Consequence
Experimenter: "Point to the feline."	*Correct:* Pointing to the exemplar of a feline	Reinforcement in the form of praise or playful physical contact (i.e., tickles)
	*Incorrect:* The absence of a response or pointing to a non-exemplar	The implementation of the correction procedure, which involved the experimenter modeling the correct response then giving the participant a chance to respond independently.

Data from listener training sessions were analyzed using the CABAS® Decision Protocol (Keohane & Greer, 2005). Table 13 briefly describes decisions made under the decision tree protocol. If the data demonstrated three data paths of no trend, five variably descending data paths, five variable data paths, three descending data paths, or two sessions at 0% correct responding the listener training was stopped, and no further training or probe sessions were conducted.

Table 13

Decision Protocol Used for Training Sessions

Decision Opportunity	Decision
Three increasing data paths	Continue the training under the current short-term objective
Five variably increasing data paths	Continue the training under the current short-term objective
Criterion met	Stop the training and move on to the next short-term objective or assessment
Three descending data paths	Stop training sessions
Three data paths of no trend	Stop training sessions
Five variably descending data paths	Stop training sessions
Two sessions with 0% accuracy	Stop training sessions

Derived relation test for speaker responses (phase 1). During each phase 1 probe session, participants were assessed on their responses to mutually entailed frames of coordination. Responses of mutual entailment consisted of the participant emitting an intraverbal tact for probe trials assessing their demonstration of B → A relations. For each session, the participant received two opportunities to respond to each 2D stimulus for a total of 20 opportunities, and 10 opportunities for each stimulus class. Assessment for mutual entailment was run using probe trials with no reinforcement or correction of responses. Criterion for the demonstration of mutual entailment was 80% correct responding in one session.

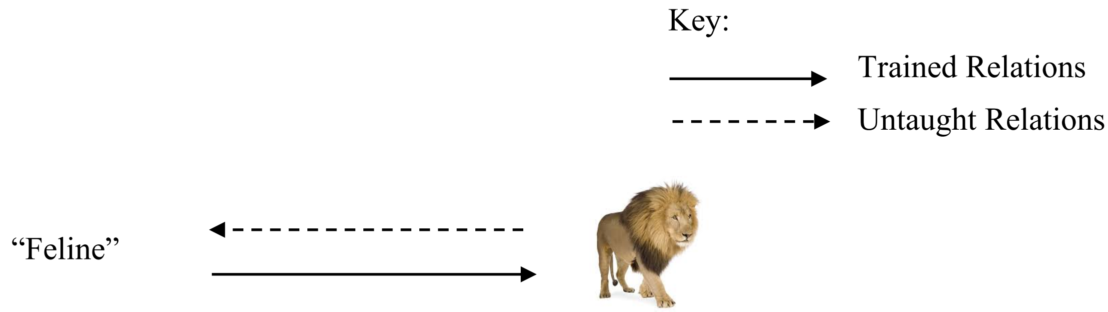


Figure 1. Example of relations taught and assessed in Phase 1.

During each session, the participant was seated across from the experimenter, while the experimenter presented the stimuli in the visual field of the participant. After gaining the participant's attention, the experimenter pointed to the I-Pad and presented the antecedent (e.g., "What is this?"); the participant was given 5 s to respond. If the participant emitted the intraverbal tact for the stimulus, the response was recorded as correct. If the participant did not emit the intraverbal tact for the stimulus, the response was recorded as incorrect.

Table 14

Description of a Probe Trial for Derived Relation Test Phase 1 and 2

Antecedent	Behavior	Consequence
Experimenter: "What is this?" "What class is this?" 	*Correct:* Saying the correct class of the animal represented (i.e., feline) *Incorrect:* The absence of a response or emitting an incorrect name	N/A

Listener training (phase 2). Listener training for phase 2 consisted of the participant learning to identify two additional classes of stimuli (i.e., serpent and mollusk), with a point response. The procedure for this training was conducted in the same manner as described for phase 1.

Derived relation test for speaker responses (phase 2). The procedure for this assessment phase was conducted in the same manner as described for phase 1.

Table 15

Exemplars of Stimuli Used for Listener Training Phase 1 and 2

	Phase 1	Phase 2
	Lion	Fly
	Panther	Ant
Phase 1	House Cat	Ladybug
(Feline & Insect)	Bob Cat	Beetle
	Cougar	Bee
	Tiger	Dragonfly
		Grasshopper
		Wasp
Phase 2	Coral Snake	Snail
(Serpent & Mollusk)	Scarlet King Snake	Oyster
	Boa Constrictor	Clam
	Python	Scallop
	Garden Snake	Mussel
	King Cobra	

Note. Different exemplars of each animal were used for each set. While a type of animal might have appeared in both set 1 & 2 the exemplar used was different.

Listener training (phase 3). In this training phase, the participants learned to conditionally relate a stimulus within Phase 1 to a stimulus within Phase 2, under a new arbitrary stimulus class (i.e., feline/serpents = “ver” for vertebrate and insects/mollusks = “int” for invertebrate). For each session, the participant received 10 opportunities for each arbitrary stimulus class, for a total of 20 opportunities for the session. The criterion for this training phase was 90% correct responding across two consecutive sessions or 100% correct responding in one session, for each stimulus class.

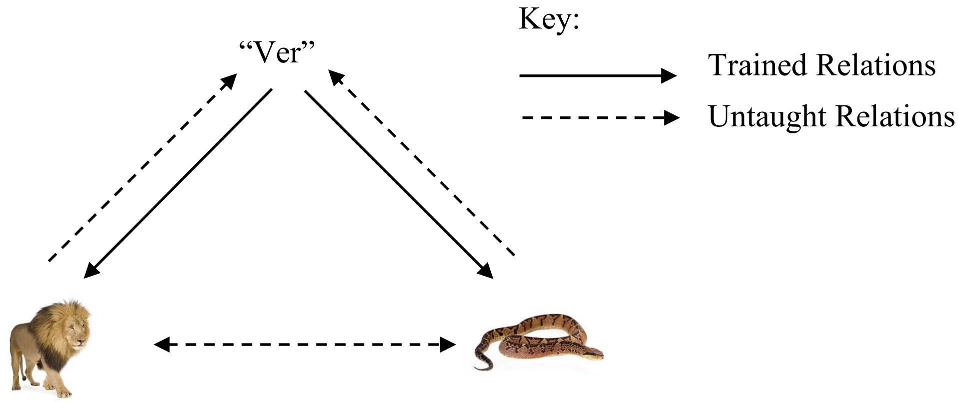


Figure 2. Example of relations taught and assessed in Phase 3.

During each phase 3 training session, the participant was seated across from the experimenter and the stimuli were displayed on the I-Pad. The screen showed one target exemplar positioned at the top of the screen and three stimuli that lined the bottom of the screen; the three stimuli on the bottom of the screen consisted of one target exemplar and two non-target exemplars. One non-target exemplar was a stimulus from the other experimental class being trained; the second non-target exemplar was a novel stimulus that was not trained in any phase of the experiment. After the visual stimuli were presented, the experimenter pointed to the target stimulus (i.e., feline) and presented the vocal antecedent "felines are ver, can you point to another animal that is ver"; after which the participant was given 5 s to respond. If the participant pointed to the target exemplar (i.e., serpent) the response was recorded as correct and behavior specific praise was delivered to the participant; the experimenter then drew a line between the two target stimuli. If the participant pointed to a non-exemplar, the response was recorded as incorrect, and the correction procedure was implemented. The correction procedure was implemented as is described in listener training Phase 1.

Table 16

Description of the Learn Unit for Listener Training Phase 3

Antecedent	Behavior	Consequence
Experimenter: "This is a ver*, can you point to the other ver."	*Correct:* Pointing to the picture of an animal that is in the class of ver (i.e., vertebrate)	Reinforcement in the form of praise or playful physical contact (i.e., tickles)
 	*Incorrect:* The absence of a response or pointing to a non-exemplar (i.e., a picture of an animal that does not correspond)	The implementation of the correction procedure, which involved the experimenter modeling the correct response then giving the participant a chance to respond independently.

Derived relation test for listener and speaker responses (phase 3). During the phase 3 probe sessions, participants were assessed on mutually entailed and combinatorially entailed frames of coordination.

Mutual entailment (phase 3). Responses of mutual entailment consisted of the participant emitting a point and intraverbal tact for probe trials assessing their demonstration of B → A and C → A relations. For each session, the participant received five opportunities to respond to each stimulus class for a total of 10 opportunities for the point response and 10 opportunities for the intraverbal tact response. Assessment for mutual entailment was run using probe trials with no reinforcement or correction of responses. Criterion for the demonstration of mutual entailment was 80% correct responding in one session with novel stimuli.

For assessment of the point response, the participant was seated across from the experimenter and stimuli was displayed on the I-Pad. The screen showed three pictures, in varying locations for each slide. After gaining the participant's attention, the experimenter presented the antecedent "Point to the animal that is ver". The participant was given 5 s to respond; if the participant pointed to the target stimulus, the response was recorded as correct. If the participant did not point to the target stimulus or emitted no response, the trial was recorded as incorrect. For assessment of the intraverbal tact response, the experimenter presented the I-Pad which displayed one picture of an animal. After gaining the participant's attention, the experimenter presented the antecedent "Felines are …", and the participant was given 5 s to respond. If the participant emitted the correct arbitrary stimulus class for the animal (i.e., ver) the response was recorded as correct; if the participant did not emit the target intraverbal, or emitted no response, the trial was recorded as incorrect.

Combinatorial entailment (phase 3). Responses of combinatorial entailment consisted of the participant emitting intraverbal tact and intraverbal responses for probe trials assessing their demonstration of C → B and B → C relations. A total of 14 intraverbal tact responses and four intraverbal responses were assessed, for a total of 18 responses of combinatorial entailment. Assessment for combinatorial entailment was run with probe trials; therefore, there was no reinforcement or correction of responses. Criterion for the demonstration of combinatorial entailment was 80% correct responding in one session with novel stimuli.

For assessment of the first intraverbal tact response, the experimenter presented the I-Pad which showed two stimuli within an arbitrary stimulus class (i.e., a mollusk and insect). The experimenter then presented the antecedent “What are these?”. A correct response was recorded if the participant emitted the arbitrary stimulus class (i.e., int or invertebrate). An incorrect response was recorded if the participant emitted no responses after 5 s or emitted the wrong stimulus class.

During the second intraverbal tact response, the experimenter presented a picture of an animal (i.e., a feline), along with the antecedent "Can you name an animal that is like this one?". A correct response was recorded if the participant said a different animal within that arbitrary stimulus class (i.e., serpent). An incorrect response was recorded if the participant said an animal, outside of the arbitrary stimulus class, or if the participant emitted no response within 5 s of the antecedent. Intraverbal responses were conducted with the same procedure, without any visual stimuli.

Table 17

Description of Probe Trials for Derived Relation Test Phase 3

Antecedent	Behavior	Consequence
"Point to the ver."   	*Correct:* Pointing to the corresponding picture stimuli *Incorrect:* The absence of a response, or pointing to a non-exemplar (i.e., a picture of an animal that does not correspond)	N/A
"Felines are ____." 	*Correct:* Saying the name of the class of the given animal (i.e., ver) *Incorrect:* The absence of a response or saying the wrong class	N/A
"What are these" "Why is this one like this"  	*Correct:* Saying the name of the class both pictures are in (i.e., ver) *Incorrect:* The absence of a response or saying the wrong class	N/A
"This is a ver, can you tell me the name of another ver?" 	*Correct:* Saying an animal sub-category which is in the class of vertebrate (i.e., serpent) *Incorrect:* The absence of a response, or saying the name of a subcategory that is not a vertebrate	N/A
"Felines are ver, can you tell me another animal that is ver."	*Correct:* Saying the name of a vertebrate (i.e., serpents) *Incorrect:* The absence of a response, or saying the name of a subcategory that is not a vertebrate	N/A

Experimental Design

The study employs a descriptive analysis of preschool students' degree of BiN, arbitrary derived relations, and non-arbitrary relational responses (Gall, 2007). The purpose of this design is to determine any particular relations between BiN and the establishment of relational responses. The variables detailed in this study were not experimentally controlled or treated. The covariables within the experiment were the degree of BiN with familiar and unfamiliar stimuli and the degree of arbitrary and non-arbitrary relations. Participants were separated into four groups, and stimuli were counterbalanced across each group. See Figure 3 for the procedural sequence for each experimental group. An Analysis of Variance (ANOVA) was conducted and demonstrated the stimuli sets and procedural sequence did not significantly affect the participants' demonstration of Bidirectional Naming, $F(3, 27) = .052$, $p = .941$, or derived relations, $F(3, 12) = .058$, $p = .981$.

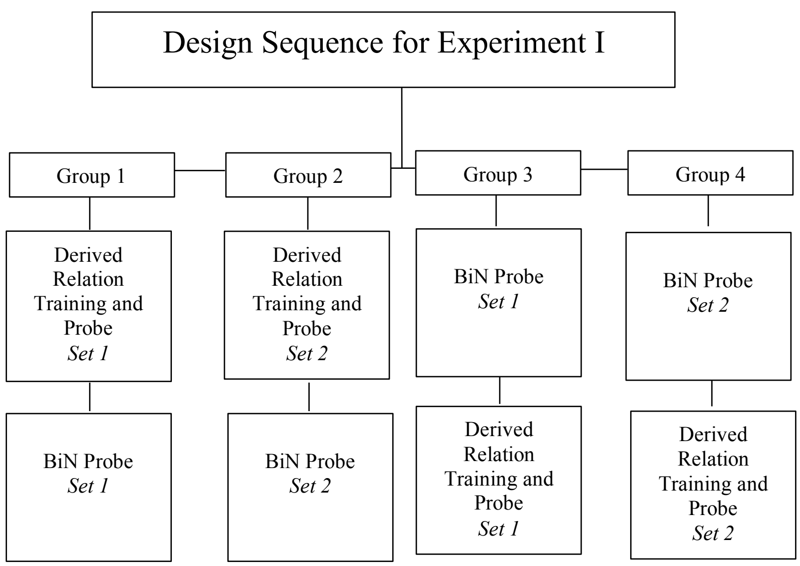


Figure 3. Procedural sequence for groups in Experiment I.

Interobserver Agreement

A second observer simultaneously and independently collected data to calculate interobserver agreement. All second observers were either classroom teachers, classroom teaching assistants, or program supervisors in a CABAS® accredited school. In addition, all second observers were calibrated and trained in the delivery of the learn unit (Albers & Greer, 1991). Each observer was required to demonstrate criterion of 10 consecutive sessions with 100% interobserver agreement for programs run using the learn unit. Interobserver agreement was calculated for each session by dividing the number of agreements by the total number of agreements and disagreements. Interobserver agreement was conducted for 64% of BiN probes, with a mean agreement of 99.91% and a range of 97.5-100%. Interobserver agreement was conducted for 47% of derived relation probes, with a mean agreement of 99.66% and a range of 97.5-100%.

Results

The Overall Relation Between Bidirectional Naming and Derived Relations

The first research question asked about the strength and direction of the relation between the participants' overall degree of BiN and their overall degree of arbitrary and non-arbitrary derived relations. An alpha level of .05 was used for all statistical tests related to this question. To analyze the relation between BIN and the establishment of arbitrary and non-arbitrary relations a chi-square test of independence was performed and demonstrated the relationship between these variables was significant, X^2 (1, N = 31) = 9.644, p = .002. To analyze the results of participants that completed all phases of the derived relation trainings (i.e., participants that did not have a graphical decision to stop derived relation training), a Pearson product-moment correlation coefficient was computed and demonstrated that there was a significant correlation between their overall degree of Bidirectional Naming and their overall degree of derived relations, $r(16) = .847$, $p < .001$, as well as with Unidirectional Naming and derived relations, $r(16) = .726$, $p < .001$. In addition, when analyzing the relation between the participants' Boehm scores and their degree of Bidirectional Naming, there was a significant correlation, $r(31) = .368$, $p = .042$. These data demonstrated a positive relationship between the participants' overall degree of Bidirectional Naming and derived relations, meaning that as the correct responding in one variable increased an increase occurred in the remaining variable; this suggests an underlying relationship between these two variables. Figure 4 and 5 show scatterplots that graphically illustrates these data. Table 18 shows the correlation coefficients for the overall relations between the primary dependent variables.

Table 18

Summary of Overall Correlations Between the Main Dependent Measures

	Overall Derived Relations	Arbitrarily Applicable Derived Relations	Non-Arbitrarily Applicable Derived Relations
Overall Bidirectional Naming	.847***	.790***	.404
Overall Unidirectional Naming	.726**	.686**	.291

Note. Significance levels: **p* < .05, ***p* < .01, ****p* < .001.

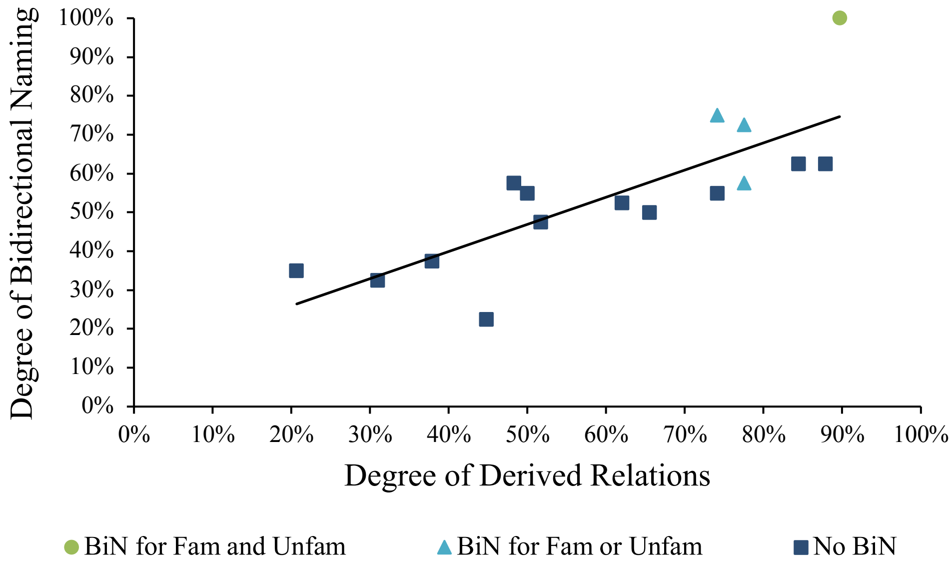


Figure 4. The participants' percentage of BiN with familiar and unfamiliar stimuli, as related to their percentage of correct arbitrary and non-arbitrary derived relations.

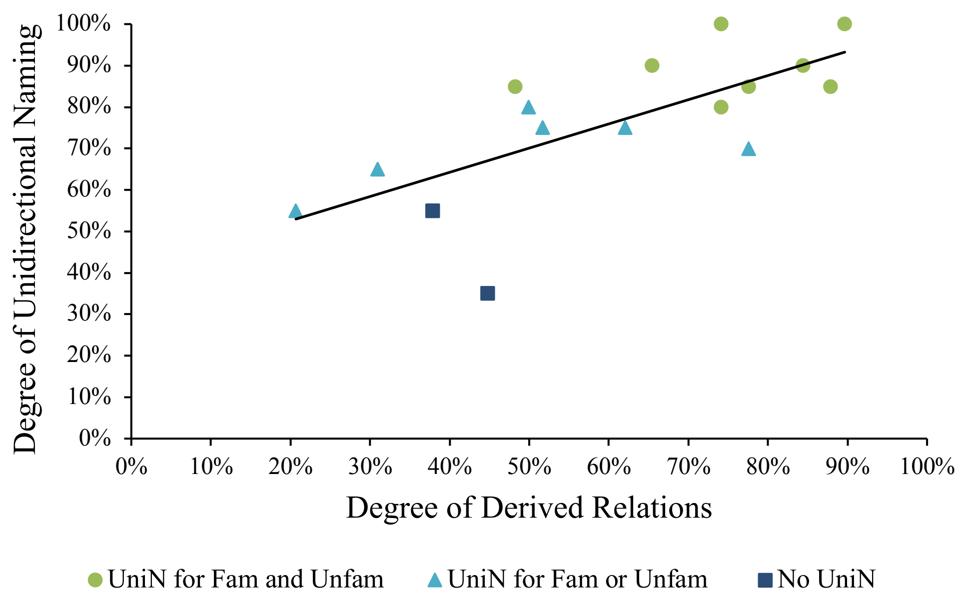


Figure 5. The participants' percentage of UniN with familiar and unfamiliar stimuli, as related to their percentage of correct arbitrary and non-arbitrary derived relations.

Overall relation when controlling for Boehm-3. A partial correlation was run to determine the relation between the participants' overall degree of Bidirectional Naming and their degree of derived relations while controlling for their Boehm percentage score; this was analyzed to ensure the relations demonstrated weren't solely due to other underlying verbal repertoires. There was a strong positive partial correlation between the two variables when controlling for age (M = 71.29, SD = 22.98), which was statistically significant, $r(13) = .739$, $n = 16$, $p = .002$. This analysis showed that the participants' demonstration of basic concepts, as measured through the *Boehm Test of Basic Concepts – 3,* was not a confounding variable in the relation between BiN and derived relations, being that while controlling for this variable there remained a strong statistical relation.

Overall relation when controlling for age. A partial correlation was run to determine the relation between the participants' overall degree of Bidirectional Naming and their degree of derived relations while controlling for age, due to the wide range in ages for the participant sample. There was a strong positive partial correlation between the two variables when controlling for age (M = 4.15, SD = .53), which was statistically significant, $r(13) = .729$, $n = 16$, p =.002. This analysis demonstrated that the participants' range of age did not have a significant effect on the relation between BiN and derived relations, being that while controlling for age there remained a strong statistical relation.

Bidirectional Naming and the Types of Derived Relations Established

The first research question also asked if there were major differences between the participants' demonstration of derived relations as related to BiN with familiar stimuli and BiN with unfamiliar stimuli. There was a significant correlation between BiN with unfamiliar stimuli and arbitrary derived relations, $r(16) = .828$, $p < .001$, as well as a significant correlation between UniN with unfamiliar stimuli and arbitrary derived relations, $r(16) = .652$, $p = .006$. Figure 6 and 7 show scatterplots that graphically illustrates these data. There was no significant correlation between BiN with familiar stimuli and arbitrary derived relations, $r(16) = -.014$, $p = .960$, or non-arbitrary relations, $r(23) = .249$, $p = .358$. In addition, there was no significant correlation between UniN with familiar stimuli and arbitrary relations, $r(16) = .291$, $p = .275$, or non-arbitrary relations, $r(23) = .259$, $p = .233$. These data demonstrated a strong positive relation between BiN with unfamiliar stimuli and arbitrary derived relations, and no correlation for BiN with familiar stimuli, which suggests that abstract derived relations are more closely related to the demonstration of BiN with unfamiliar stimuli.

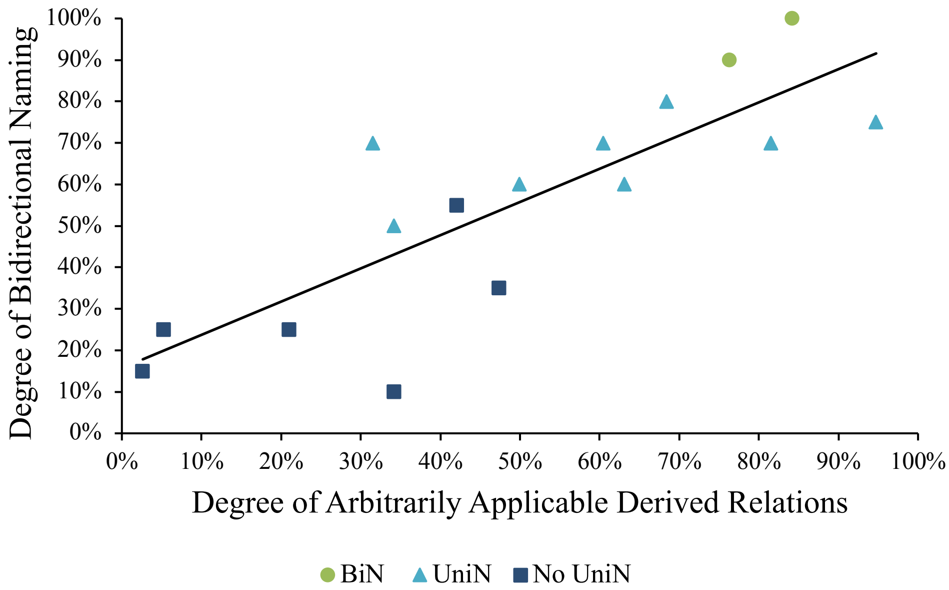


Figure 6. The participants' percentage of BiN with unfamiliar stimuli, as related to their percentage of correct arbitrarily applicable relational responses.

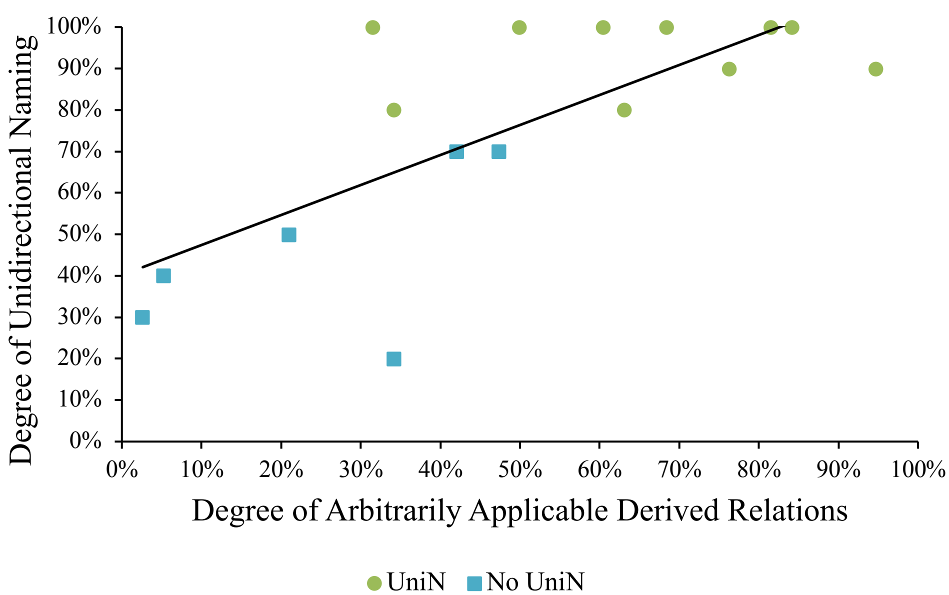


Figure 7. The participants' percentage of UniN with unfamiliar stimuli, as related to their percentage of correct arbitrarily applicable relational responses.

Bidirectional Naming and the Properties of Derived Relations Established

The second research question asked whether there was a relation between the property of the derived relation (i.e., mutually entailed or combinatorially entailed), and the participants' degree of Bidirectional Naming. An alpha level of .05 was used for all statistical tests related to this question. A Pearson's product-moment correlation coefficient was conducted and demonstrated there was a significant correlation between mutually entailed relational frames and the participants' overall degree of Bidirectional Naming, $r(16) = .803$, $p < .001$. Moreover, there was a significant correlation between mutually entailed relational frames and the participants' degree of Bidirectional Naming with unfamiliar stimuli, $r(16) = .853$, $p < .001$. Figure 8 shows a scatterplot that graphically illustrates these data. In addition, there was a significant correlation between mutually entailed relational frames and the participants' overall Unidirectional naming, $r(16) = .697$, $p = .003$. Moreover, there was a significant correlation between mutually entailed relational frames and the participants' degree of Unidirectional Naming with unfamiliar stimuli, $r(16) = .826$, $p < .001$. Figure 10 shows a scatterplot that graphically illustrates these data. A significant correlation was also found between combinatorially entailed relational frames and the participants' overall degree of Bidirectional Naming, $r(16) = .625$, $p = .010$. Moreover, a significant correlation was found between combinatorially entailed relational frames and the participants' degree of Bidirectional Naming with unfamiliar stimuli, $r(16) = .614$, $p = .011$. Figure 9 shows a scatterplot that graphically illustrates these data. There was also a significant correlation between combinatorially entailed relational frames and the participants' overall degree of Unidirectional Naming, $r(16) = .653$, $p = .006$. Figure 11 shows a scatterplot that graphically illustrates these data. Table 19 shows a table summarizing the correlation coefficients for all dependent measures. Overall, these data demonstrate that as the participants' overall degree of Bidirectional Naming increased, their overall responses to mutually entailed and combinatorially entailed relations also increased.

Table 19

Summary of Correlations Between All Dependent Measures

		Arbitrary and Non-Arbitrary Derived Relations	
		Mutually Entailed	Combinatorially Entailed
Bidirectional Naming	Combined	.803***	.625***
	Familiar Stimuli	.124	.461
	Unfamiliar Stimuli	.853***	.614*
Unidirectional Naming	Combined	.697**	.653**
	Familiar Stimuli	.218	.462
	Unfamiliar Stimuli	.826**	.419

Note. Significance levels: $*p < .05$, $**p < .01$, $***p < .001$, $n=16$.

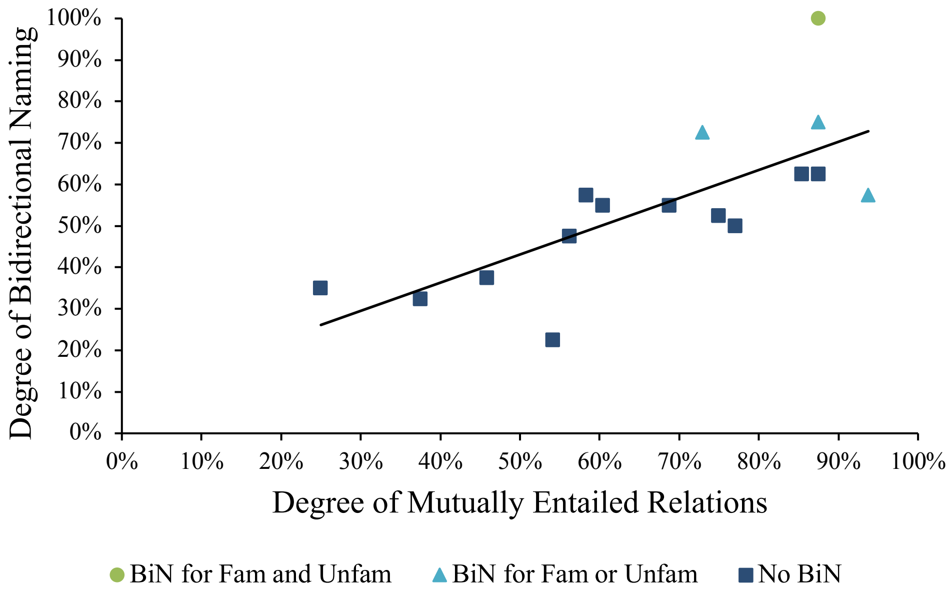


Figure 8. The participants' degree of BiN with familiar and unfamiliar stimuli, as related to their percentage of correct mutually entailed relational responses.

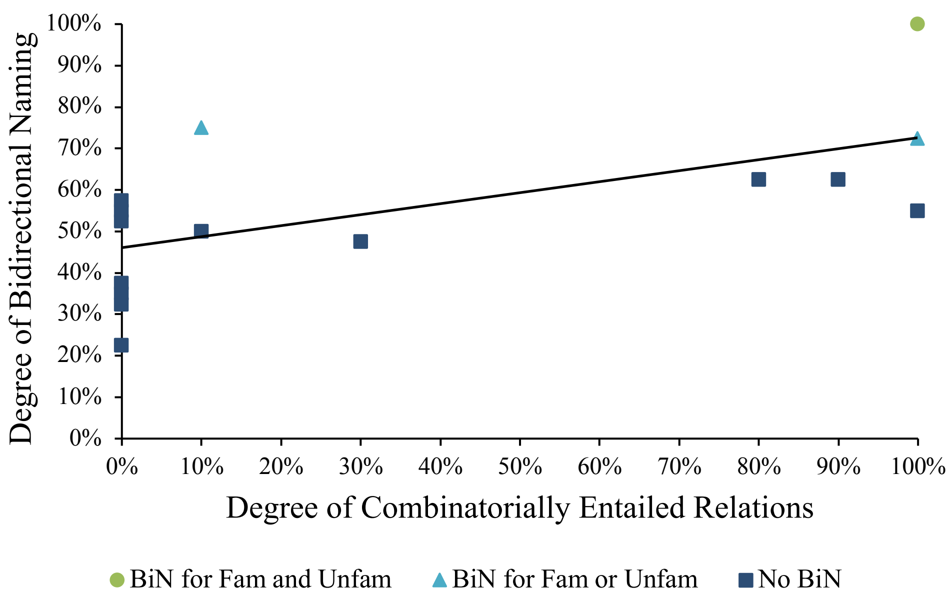


Figure 9. The participants' degree of BiN with familiar and unfamiliar stimuli, as related to their percentage of correct combinatorially entailed relational responses.

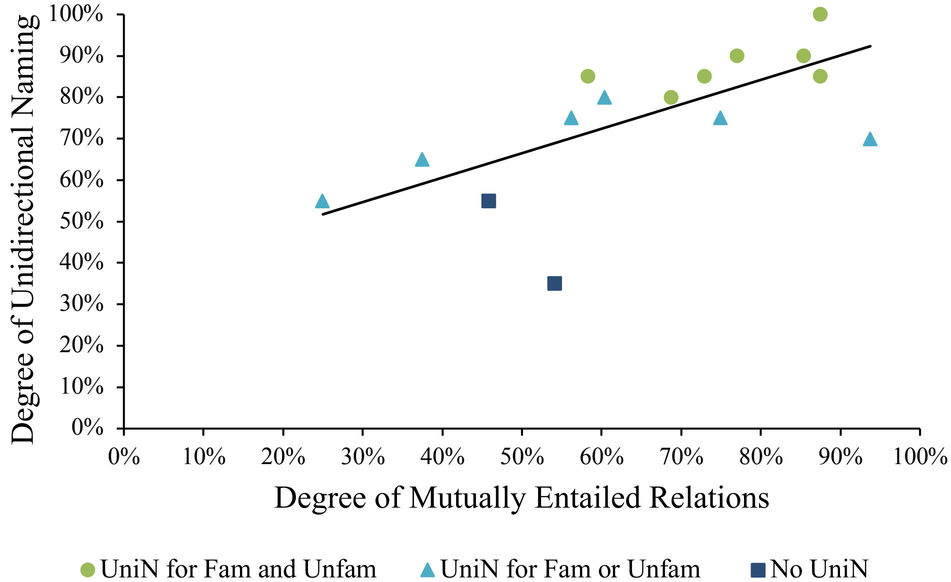


Figure 10. The participants' degree of UniN with familiar and unfamiliar stimuli, as related to their percentage of mutually entailed relational responses.

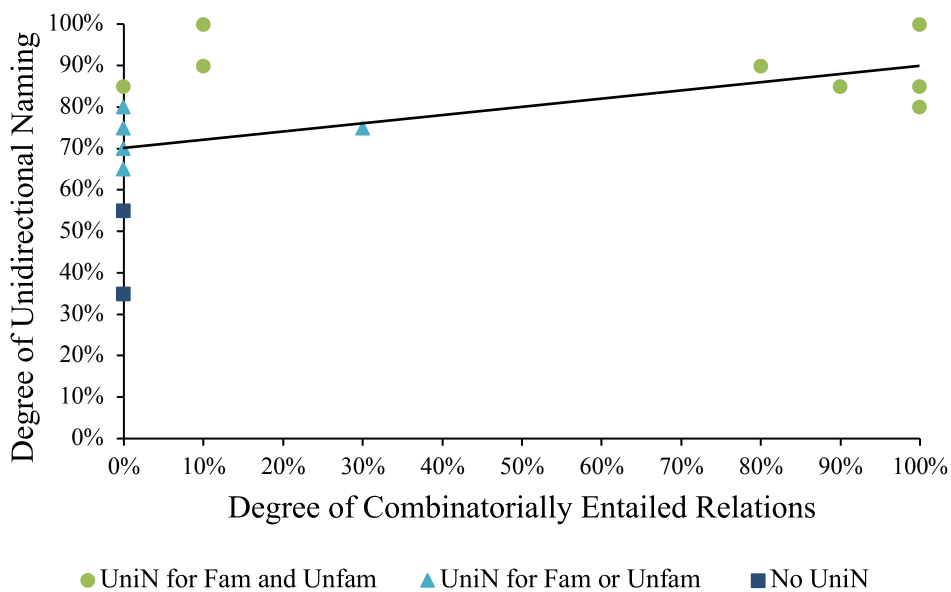


Figure 11. The participants' degree of UniN with familiar and unfamiliar stimuli, as related to their percentage of combinatorially entailed relational responses.

The Role of Visual Stimuli in the Establishment of Derived Relations

The third research question analyzed the role of visual stimuli in the participants' establishment of intraverbal derived relations. An alpha level of .05 was used for all statistical tests related to this question. A paired-samples t-test was conducted to compare the means for derived relations emitted as intraverbal and intraverbal tacts; the analysis demonstrated there was no a significant difference in the participants' emission of intraverbals ($M = 1.44$, $SD = 1.59$) and intraverbal tacts ($M = 1.56$, $SD = 1.504$), $t(15) = -.620$, $p = .544$. These data demonstrated that the visual stimulus had no significant effect on the participants' production of correct derived relations.

Secondary Findings

Along with the results analyzed for the research questions, there were other serendipitous findings; the following sections details these findings. An alpha level of .05 was used for all analyses in this section.

The effect of the participants' level of BiN on training sessions. A Pearson's product-moment correlation coefficient was conducted and demonstrated that there was a positive correlation between the participants' percentage of correct responses and their degree of BiN, $r(31) = .477$, $p = .007$. Figure 12 shows a scatterplot that graphically illustrates these data. These data demonstrated that as the participants' degree of BiN increased their percentage of correct responses during derived relation training also increased.

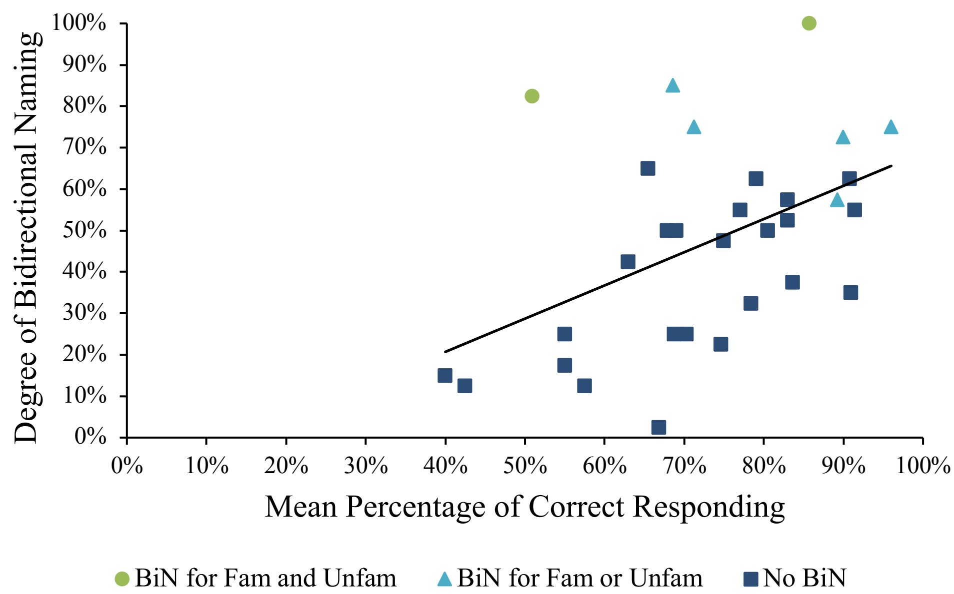


Figure 12. The participants' percentage of BiN with familiar and unfamiliar stimuli, as related to their percentage of correct responses during derived relation training phases.

The dependent measures in relation to demographic variables. The following analyses measured the association of the main dependent variables in relation to the demographic variables used to describe the participants. First, when using a Pearson's product moment correlation coefficient to analyze the students' demonstration of BiN and relational responses in relation to their socioeconomic status there was no significant correlation for both Bidirectional Naming, $r(31) = .169$, $p = .364$, and derived relations, $r(16) = .020$, $p = .943$. This analysis demonstrated that the participants' socioeconomic status was not related to their demonstration of BiN or derived relations; however, it is important to note that the measure used to ascertain their socioeconomic status was based on a secondary source.

An independent samples t-test was used to analyze the difference in the participants' demonstration of Bidirectional Naming and derived relations based on their sex. When analyzing the difference in the establishment of derived relations for boys (n = 13, M = 57.95, SD = 21.75) and girls (n = 3, M = 74.71, SD = 12.93) there was no statistical difference, $t(14) = -1.26$, $p = .228$. When analyzing the difference in Bidirectional Naming for boys (n = 23, M = 45.10, SD = 23.56) and girls (n = 8, M = 52.18, SD = 27.94) there was no statistical difference, $t(29) = -6.98$, $p = .491$. These analyses demonstrated that the participants' sex was not related to their demonstration of BiN or derived relations; however, it is important to note that the number of girls in the sample was very low.

Participants' distribution of BiN based on participants dropped. Based on the training method used for derived relations, participants were dropped from some analyses if they demonstrated the need for a tactic; the need for a tactic was assessed by an analysis of the participants' graphed data using the decision protocol (Keohane & Greer, 2005). Group B represented students that completed listener training phase 1 and 2 and thus were assessed for non-arbitrary relational responses. An ANOVA was used to analyze the difference between the participants' degree of BiN and demonstrated there was no significant difference between participants within the group and participants dropped from the group, $F(1, 29) = 3.29$, $p = .080$. Group A represented students that completed listener training phases 1-3 and thus were assessed for all relations. An ANOVA was used to analyze the difference between the participants' degree of BiN and demonstrated there was a significant difference between participants within the group and participants dropped from the $F(1, 29) = 22.33$, $p < .001$. These analyses demonstrated that while there was no difference in the participants' demonstration of BiN in group B, group A was compromised of participants' with a higher degree of BiN.

Discussion

The findings from Experiment I demonstrated a moderate correlation between nominal variables for all dependent measures and a strong positive correlation between scale variables. These relations demonstrate that as the percentage of correct responding increases for one variable, it also increases for the other variable. These data support research which has suggested that while derived relations are possible in individuals with low verbal repertoires, the verbal repertoire does interact with the individual's establishment of derived relational responses (Kobari-Wright & Miguel, 2014; Lee et al., 2015; Miguel & Kobari-Wright, 2013; Miguel et al., 2008). This is further demonstrated in the analysis of the participants' correct responses in relation to their degree of BiN, which demonstrated that as the participants' degree of BiN increased their number of correct responses to the derived relation training also increased.

Further, the data demonstrated that there was a strong positive correlation between both BiN and UniN with unfamiliar stimuli and arbitrary derived relations but did not demonstrate a significant correlation between BiN and UniN with familiar stimuli and non-arbitrary relational responses. This suggests that there is a relationship that is only discernable with higher-level manifestations of these repertoires. In addition, it also suggests that speaker-as-own listener behavioral cusps like BiN and other higher-level verbal problem-solving repertoires are needed for the demonstration of arbitrary derived relations.

Similar to data described above, BiN and UniN with familiar stimuli were not correlated with the participants' demonstration of mutually entailed and combinatorially entailed derived relations. However, the participants' degree of UniN with unfamiliar stimuli was correlated with mutually entailed derived relations, and BiN with unfamiliar stimuli was correlated to both mutually and combinatorially entailed derived relations. These data further show a pattern between demonstrations of higher-level derived relations (i.e., arbitrary derived relations and combinatorially entailed relations) and demonstrations of higher-level BiN cusps (i.e., BiN with unfamiliar stimuli and UniN with unfamiliar stimuli). See Table 18 and 19 for tables summarizing the correlation coefficients between BiN and derived relations.

Finally, regarding the third research question, a paired sample t-test was conducted and demonstrated there was not a significant difference between participants' responses to intraverbal tact antecedents and intraverbal antecedents; both students with high and low degrees of BiN demonstrated correct responses to intraverbal tact and intraverbal responses suggesting that the repertoires are not dependent upon each other. Contrastingly, I believe that further research should be conducted on conditioned seeing and the participants' intraverbal and intraverbal tact responses to reveal more information on the participants' demonstration of intraverbal tact responses. That is the participants' demonstration of visualizing pictures, which are not currently present, may be a precursor in their demonstration of intraverbal tact responses for derived relations.

Rationale for Experiment II

In Experiment I the relations that were analyzed all denote auditory-visual frames of coordination, which is primarily the first frame established being that it closely mirrors everyday language exposures (Hayes et al., 2001). These frames were also analyzed due to the age of the participant sample available for the first experiment. However, to have a deeper conversation on the variety of relational frames that are possible, Experiment II analyzes frames of auditory-visual and visual-visual relations. The purpose of this study is to analyze the mean difference between groups of students with BiN to further investigate the effects of the criterion-measured presence of BiN on the establishment of cross-modal and single modal stimulus relations.

In addition, a limitation of Experiment I was that most analyses were run on a subset of participants whose data did not demonstrate the need for a tactic. Thus, the number of participants within each analysis changed based on the derived relation training phase the participant completed. To maintain a consistent number of participants across the analyses, the training procedure for Experiment II was changed to require an instance of joint attention during exposure training, rather than criterion level responding for listener training. This method was utilized because it has previously been used in other data-based assessments of derived relations.

Research Question for Experiment II

1. How does the criterion-measured presence of Bidirectional Naming alter the way that individuals acquire different types of relational frames (i.e., auditory-visual relations and visual-visual relations)?

CHAPTER III

EXPERIMENT II

Method

Participants

Participants were 18 preschool students, selected from Experiment I, whose ages ranged from 3.4 to 5.1 at the onset of the study (*M* = 4.11, *SD* = .57). Participants were chosen for the present study and grouped based on their demonstration of BiN. The first experimental group was comprised of six students that demonstrated low degrees of BiN across familiar and unfamiliar stimuli (i.e., ≤ 50%). The second experimental group was comprised of six students that demonstrated UniN across familiar and unfamiliar stimuli (i.e., ≥ 70%) with a low degree of speaker responses. The third experimental group was comprised of six students that demonstrated the presence of BiN across familiar and unfamiliar stimuli (i.e., ≥ 70%). Table 20 and 21 describe the participants for each experimental group.

Table 20

Description of Participants in Experiment II

		Low BIN		UniN		Full BiN	
Variable		*N*	Percent	*N*	Percent	*N*	Percent
Gender		M = 4	M = 66%	M = 4	M = 66%	M = 3	M = 50%
		F = 2	F = 44%	F = 2	F = 44%	F = 3	F = 50%
Diagnosis/Classification		6	100%	5	83%	4	66%
English Language Learner		1	16%	1	16%	1	16%
	0-4.9%	2	33%	1	16%	0	0%
Neighborhood	5-9.9%	0	0%	3	50%	0	0%
Poverty Level	10-19.9%	3	50%	2	33%	3	50%
	≥ 20%	1	16%	0	0%	3	50%
Boehm Percentile	Rank 1	5	83%	4	66%	2	33%
Rank	Rank 2	1	16%	1	16%	1	16%
	Rank 3	0	0%	1	16%	2	33%

Table 21

Race/Ethnicities of Participants in Experiment II

	Low BiN		UniN		Full BiN	
Race/Ethnicity	*N*	Percent	*N*	Percent	*N*	Percent
White	2	16%	2	33%	3	50%
African American	1	0%	1	16%	0	0%
Hispanic/Latino	2	33%	3	50%	3	50%
Asian	1	33%	0	0%	0	0%

Setting and Materials

The experimental setting for this experiment was consistent with what is detailed in Experiment I. Assessment materials were consistent with what is detailed in Experiment I. Stimuli used in this experiment were abstract stimuli, that were assigned contrived CVC (i.e., consonant-vowel-consonant) names. Tables 22, 23, and 24 demonstrate the stimuli used for both visual-visual and auditory-visual derived relation tests.

Table 22

Experimental Stimuli Used for Visual-Visual Derived Relations

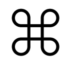
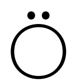
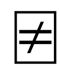
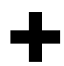
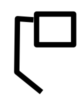
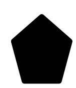
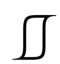
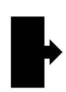
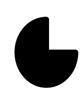
Stimuli Sets		Visual-Visual Derived Relations	
		1	2
Set 1	A		
	B		
	C		
Set 2	A		
	B		
	C		
Set 3	A		
	B		
	C		

Table 23

Experimental Stimuli Sets 1-4 Used for Auditory-Visual Derived Relations in Experiment II

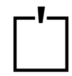
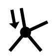
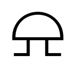
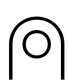
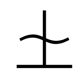
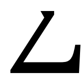
Stimuli Sets		Auditory-Visual Derived Relations 1	2
Set 1			
	A	Vat	Jem
	B		
	C		
Set 2			
	A	Ax	Vet
	B		
	C		
Set 3			
	A	Tat	Viv
	B		
	C		
Set 4			
	A	Jin	Pad
	B		
	C		

Table 24

Experimental Stimuli Sets 5-6 Used for Auditory-Visual Derived Relations in Experiment II

Stimuli Sets		Auditory-Visual Derived Relations	
		1	2
Set 5			
	A	Weg	Nob
	B	☸	
	C		
Set 6			
	A	Zi	Bay
	B	四	八
	C	五	江

Dependent Measures

The dependent variables measured for this experiment were the participants' degree of BiN and their degree of arbitrary relations established. For both auditory-visual and visual-visual relations, frames of mutual entailment (i.e., B → A and A → C) and combinatorial entailment (i.e., B → C) were assessed. Auditory-visual relations were comprised of the participant learning an equivalent relation between a spoken word and a visual stimulus. Visual-visual relations were comprised of the participant learning an equivalent relation between two visual stimuli.

Table 25

Description of Training and Assessment Sequence for Auditory-Visual and Visual-Visual Derived Relations

Relation	Phase	Trained Relation(s)	Untaught Relation(s) Assessed
Auditory-Visual	1	A1 → B1 A2 → B2	B1 → A1 B2 → A2
	2	A1 → C1 A2 → C2	C1 → A1 C2 → A2 B1 → C1 & C1 → B1 C2 → B2 & B2 → C2
Visual-Visual	1	A1 → B1 A2 → B2	B1 → A1 B2 → A2
	2	A1 → C1 A2 → C2	C1 → A1 C2 → A2 B1 → C1 & C1 → B1 C2 → B2 & B2 → C2

Note. This table displays the trials that were exposed and assessed in each phase of Experiment II. For auditory-visual relations A1 and A2 denote an auditory stimulus (i.e., the spoken name). For visual-visual relations A1 and A2 denote a visual stimulus.

Procedure

Auditory-visual relations. Assessment for auditory-visual relations consisted of the participant emitting point and intraverbal tact responses to assess for mutually entailed and combinatorially entailed derived relations. Eight listener responses and six speaker responses were measured, for a total of 14 responses for the session. Assessments for auditory-visual relations were run with probe trials with no reinforcement or correction of responses. Criterion for the demonstration of auditory-visual relations was set at 11 correct responses or 78% accuracy in one session.

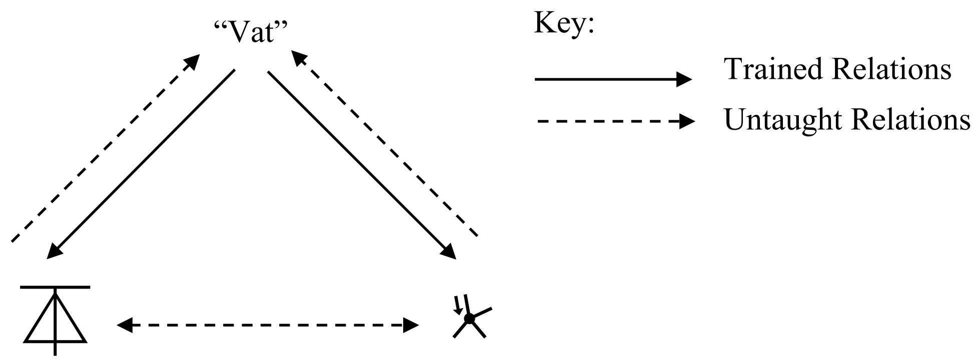


Figure 13. Example of trained and assessed auditory-visual derived relations.

Exposure training for auditory-visual relations (phase 1). Each training session consisted of 10 exposures, with five exposures for each stimulus; there were two visual stimuli for each exposure training session. For each exposure, a visual stimulus was displayed on the screen, and as the participant viewed the stimulus, the experimenter said the name of that stimulus. No response other than observation of the stimulus was required, and no consequence was delivered during exposure training.

Table 26

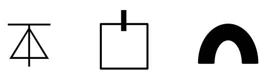
Description of Exposure Training Phase 1 for Auditory-Visual Relations

Antecedent	Behavior	Consequence
Experimenter: "This is vat" 	The participant observed the stimulus while the experimenter produced the name	N/A

Assessment of mutual entailment for auditory-visual relations (phase 1). Following exposure training, the participant was assessed for mutual entailment in listener and speaker repertoires. For assessment of listener responses, the participant was presented with three stimuli and the vocal antecedent "point to _". For assessment of speaker responses, the participant was presented with one stimulus and the vocal antecedent “what is this?”.

Table 27

Description of Probe Trials for Mutually Entailed Auditory-Visual Relations

Antecedent	Behavior	Consequence
Listener: Experimenter: "Point to vat” 	*Correct:* Pointing to the target exemplar named *Incorrect:* The absence of a response or pointing to a non-exemplar	N/A
Speaker: Experimenter: “What is this?” 	*Correct:* Saying the name of the picture presented *Incorrect:* The absence of a response or saying the name of a non-exemplar	N/A

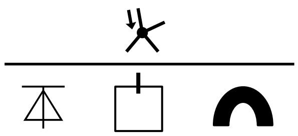
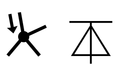
Exposure training for auditory-visual relations (phase 2). This phase of exposure training was run with the same procedure as described for Phase 1; however, the second training procedure introduced two novel visual stimuli. These stimuli were categorized in the same experimental class that was defined in phase 1.

Assessment of mutual entailment for auditory-visual relations (phase 2). Following the second exposure training, the participant was assessed for mutual entailment in listener and speaker repertoires. This procedure was run consistently with what is described in the phase 1 assessment of mutual entailment.

Assessment of combinatorial entailment for auditory-visual relations (phase 2). Participants were assessed for the demonstration of combinatorial entailment in listener and speaker responses. For listener assessment, one stimulus was placed at the top center of the screen, and three other stimuli, one target stimulus, and two non-exemplars lined the bottom of the screen. Following the presentation of the visual stimuli, the experimenter presented the vocal antecedent "Match", after which the participant was expected to point to the visual stimulus within the same experimental class as the target stimulus. During the intraverbal tact assessment, two stimuli, from the same experimental class, were presented on the screen and the participant was presented with the antecedent "What are these?" or "What are these both called".

Table 28

Description of Probe Trials for Combinatorially Entailed Auditory-Visual Relations

Antecedent	Behavior	Consequence
Listener:		
Experimenter: "Match" 	*Correct:* Pointing to the target exemplar with the same experimentally contrived name	N/A
	Incorrect: The absence of a response or pointing to a non-exemplar	
Speaker:		
Experimenter: "What are these called?" 	*Correct:* Saying the stimulus class of the pictures presented	N/A
	Incorrect: The absence of a response or saying the name of a non-exemplar	

Visual-visual relations. Assessment for visual-visual relations consisted of the participant emitting point responses to assess for mutually entailed and combinatorially entailed derived relations. There was a total of 16 responses for each session. Assessment for visual-visual relations was run with probe trials with no reinforcement or correction of responses. Criterion for the demonstration of visual-visual relations was set at 13 correct responses or 81% accuracy in one session.

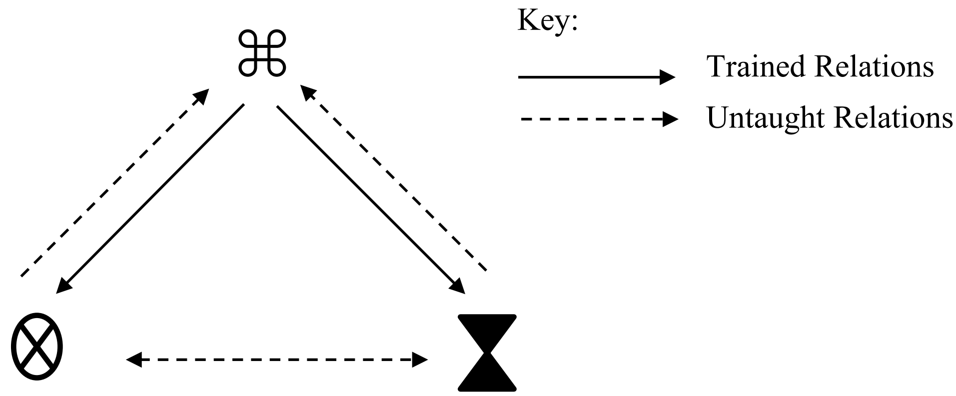
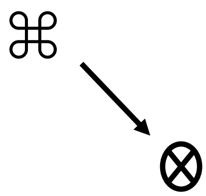


Figure 14. Example of trained and assessed visual-visual derived relations.

Exposure training for visual-visual relations (phase 1). Each training session consisted of 10 total exposures, with five exposures for each stimulus; there were two novel stimuli introduced for exposure training phase 1. For each exposure, two visual stimuli were displayed on the screen with an arrow point from stimulus to the other. As the participant was viewing the stimuli, the experimenter said, “This is the same as this”. No response other than observation of the stimulus was required, and no consequence was delivered during exposure training.

Table 29

Description of Exposure Training Phase 1 for Visual-Visual Relations

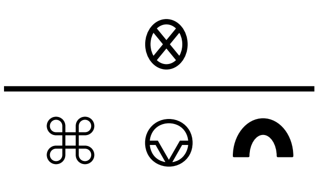
Antecedent	Behavior	Consequence
Experimenter: "This is the same as this" 	The participant observed both stimuli	N/A

Assessment of mutual entailment for visual-visual relations (phase 1).

Following exposure training, the participant was assessed for listener repertoires. For listener assessment, one stimulus was placed at the top center of the screen and three other stimuli, one target stimulus, and two non-exemplars lined the bottom of the screen. Following the presentation of the visual stimuli, the experimenter presented the vocal antecedent "point to the same".

Table 30

Description of a Probe Trial for Combinatorially Entailed Visual-Visual Relations

Antecedent	Behavior	Consequence
Experimenter: "Match" 	The participant pointed to the visual stimulus that was defined as the same within exposure training	N/A

Exposure training for visual-visual relations (phase 2). All visual-visual exposure training sessions were run with the same procedure; however, phase 2 introduced two novel visual stimuli. The new stimuli were categorized in the same experimental class that was defined in phase 1.

Assessment of mutual entailment for visual-visual relations (phase 2). Following the second exposure training, the participant was assessed for mutual entailment in listener repertoires. This procedure was run consistently with what is described in the first assessment of mutual entailment.

Assessment of combinatorial entailment for visual-visual relations (phase 2). Assessment of combinatorial entailment was run identically as the assessment described for auditory-visual combinatorially derived relations without speaker responses, however, for assessment of combinatorial entailment the participant was expected to match stimuli from the first and second exposure training.

Experimental Design

This experiment utilized a descriptive analysis to determine whether or not participants that demonstrated BiN, UniN, and low instances of BiN also demonstrated auditory-visual and visual-visual relations (Gall, 2007). The variables within in this study were not experimentally controlled or treated. The purpose of this experiment was to determine if there were any relations between the degree of BiN and the types of derived relations they demonstrated. The analysis involved three steps: (1) Participants received a probe to determine their degree of BiN for familiar and unfamiliar stimuli, (2) Participants received a probe to determine their establishment of auditory-visual relations, and (3) Participants received a probe to determine their establishment of visual-visual relations.

Interobserver Agreement

A second observer simultaneously and independently collected data to calculate interobserver agreement. All second observers were either classroom teachers, classroom teaching assistants, or program supervisors in a CABAS® accredited school. Also, all second observers were calibrated and trained in the delivery of the learn unit (Albers & Greer, 1991). Each observer was required to demonstrate criterion of 10 consecutive sessions with 100% interobserver agreement for programs run using the learn unit. Interobserver agreement was calculated for each session by dividing the number of agreements by the total number of trials. Interobserver agreement was collected for 33% of all derived relation probes, with a mean agreement of 98.25% and a range of 90-100%. Interobserver agreement was collected 61% of all BiN probes, with a mean agreement of 99.54% and a range of 95-100%.

Results

The Relation Between Auditory-Visual Relations and Bidirectional Naming

A Pearson's product-moment correlation coefficient was conducted to analyze the presence and direction of interactions between the participants' demonstration of Bidirectional Naming, and their demonstration of auditory-visual derived relations. An alpha level of .05 was used to determine the significance of the following analyses. The analysis between auditory-visual derived relations and Bidirectional Naming demonstrated a strong positive correlation, $r(18) = .809$, $p < .001$. Figure 15 provides a graphical display of these data. Further, when analyzing the relationship between BiN and the property of relations established there was a significant correlation between BiN and both mutually entailed, $r(18) = .794$, $p < .001$, and combinatorially entailed auditory-visual relations, $r(18) = .733$, $p =.001$. Figure 16 and 17 provide graphical displays of these data.

When controlling for the participants' Boehm scores as measured by their number of correct responses ($M = 78.23$, $SD = 18.40$), there was a significant relation between auditory-visual relations and the participants' degree of Bidirectional Naming, $r(14) = .807$, $n = 17$, $p < .001$. These data suggest that the relation between auditory-visual derived relations and BiN was not confounded by other verbal repertoires measured by the Boehm-3 assessment; however, the Boehm score was missing for one participant within the sample, which may have skewed this analysis.

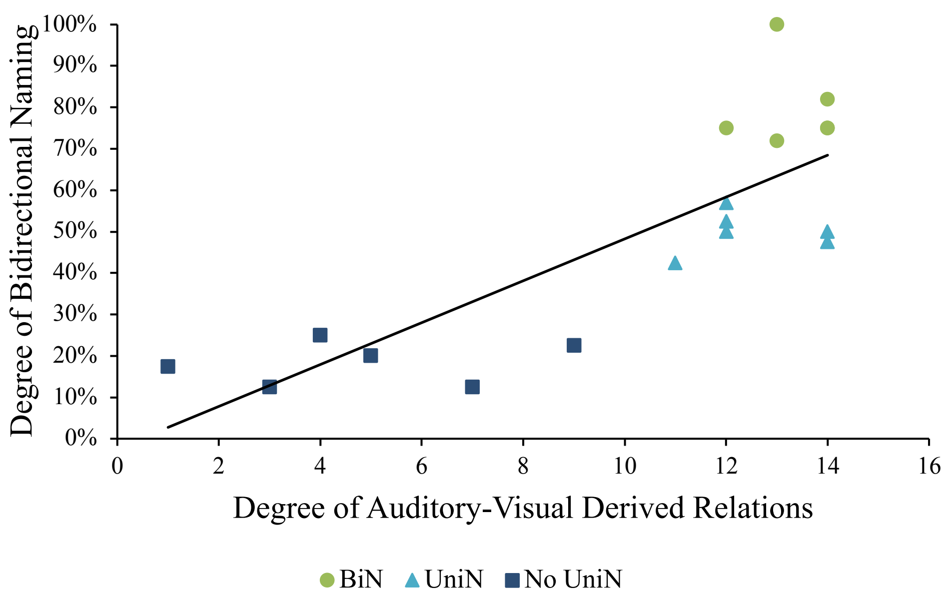


Figure 15. The participants' degree of BiN in relation to their establishment of auditory-visual relations.

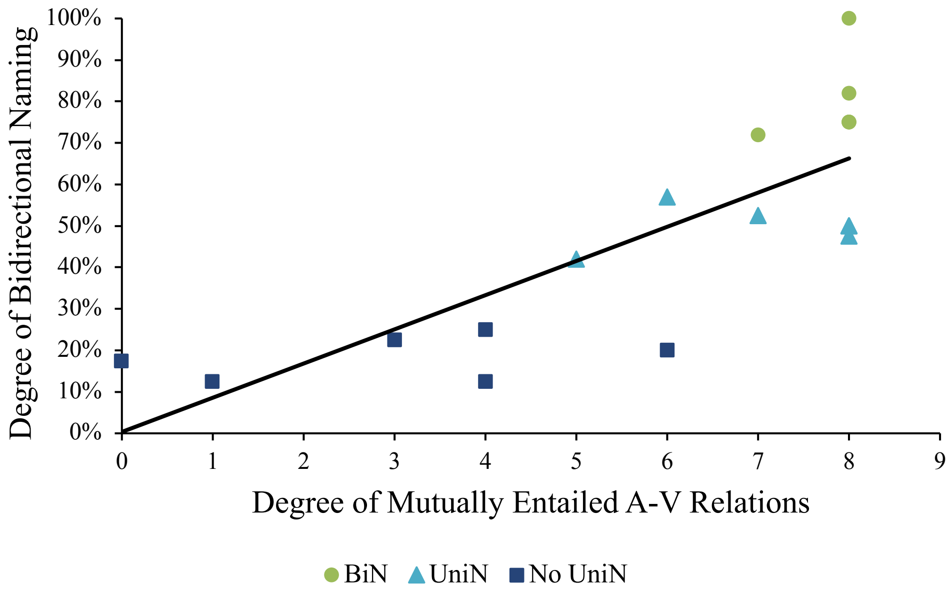


Figure 16. The participants' degree of BiN in relation to their establishment of mutually entailed auditory-visual relations.

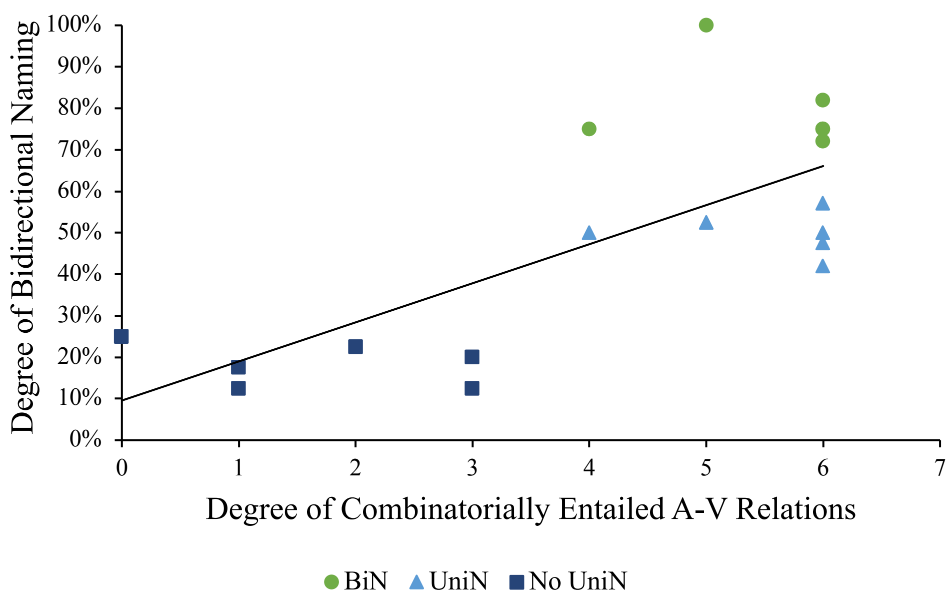


Figure 17. The participants' degree of BiN in relation to their establishment of combinatorially entailed auditory-visual relations.

The Mean Differences Between Auditory-Visual Relations and the Degree of Bidirectional Naming

An ANOVA was run to analyze the mean differences in the establishment of auditory-visual relations between the experimental groups. An alpha level of .05 was used to determine the significance of the following analyses. The results of the ANOVA demonstrated that the effect of the participants' degree of Bidirectional Naming on their auditory-visual relations was significant, $F(2,15) = 36.632$, $p < .001$. A post hoc using the Bonferroni procedure indicated that the average number of correct responses for students with no or low degree of BiN were significantly lower than students with BiN ($M = -8.67$, $SD = 1.12$, $p < .001$), and significantly lower than students with UniN ($M = -7.83$, $SD = 1.12$, $p < .001$). Figure 18 provides a graphical display of the participants' mean number of correct auditory-visual responses, as related to their level of BiN.

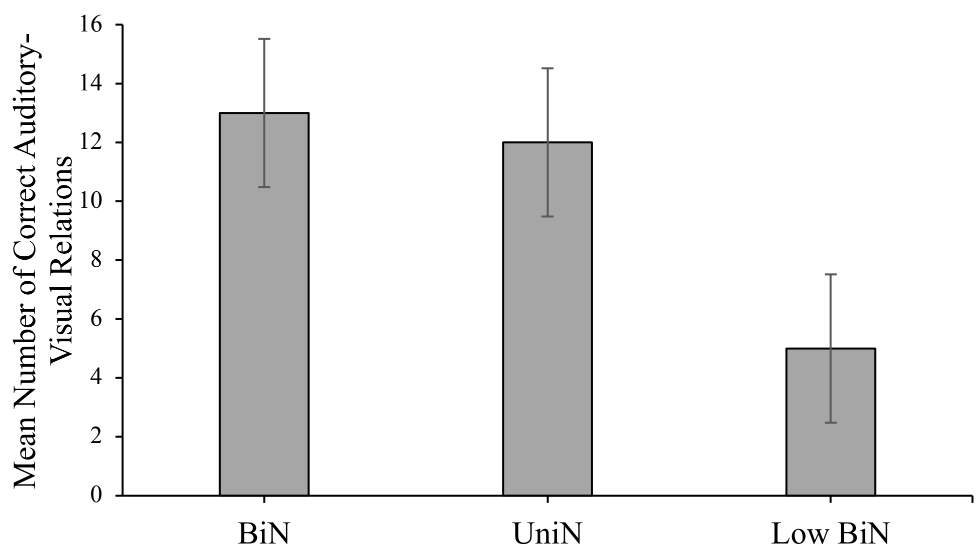


Figure 18. The mean correct responses and standard error for auditory-visual relations across all participants.

The Relation Between Visual-Visual Relations and Bidirectional Naming

A Pearson's product-moment correlation coefficient was conducted to analyze the presence and direction of interactions between the participants' demonstration of Bidirectional Naming, and their demonstration of visual-visual derived relations. An alpha level of .05 was used to determine the significance of the following analyses. The analysis between visual-visual derived relations and Bidirectional Naming demonstrated a moderate positive correlation, $r(18) = .493$, $p = .028$. Figure 19 provides a visual display of these data. Further, when analyzing the relationship between BiN and the property of relations established there was a significant correlation between BiN and mutually entailed visual-visual relations, $r(18) = .794$, $p < .001$, as depicted in Figure 20, however, there was no significant difference between BiN and combinatorially entailed visual-visual relations.

When controlling for the participants' Boehm score as measured by their number of correct responses ($M = 78.23$, $SD = 18.40$), there was not a significant relation between visual-visual relations and the participants' degree of Bidirectional Naming, $r(14) = .409$, $n = 17$, $p = .116$. These data suggest that the relation between visual-visual derived relations is confounded by other verbal repertoires measured by the Boehm-3 assessment; however, the Boehm score was missing for one participant within the sample, which may have skewed this analysis.

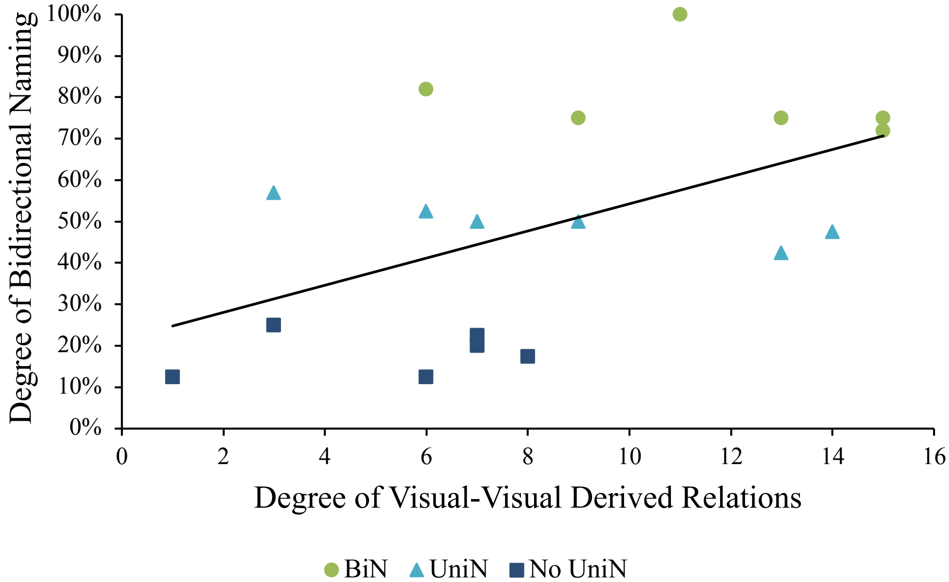


Figure 19. The participants' degree of BiN in relation to their establishment of visual-visual relations.

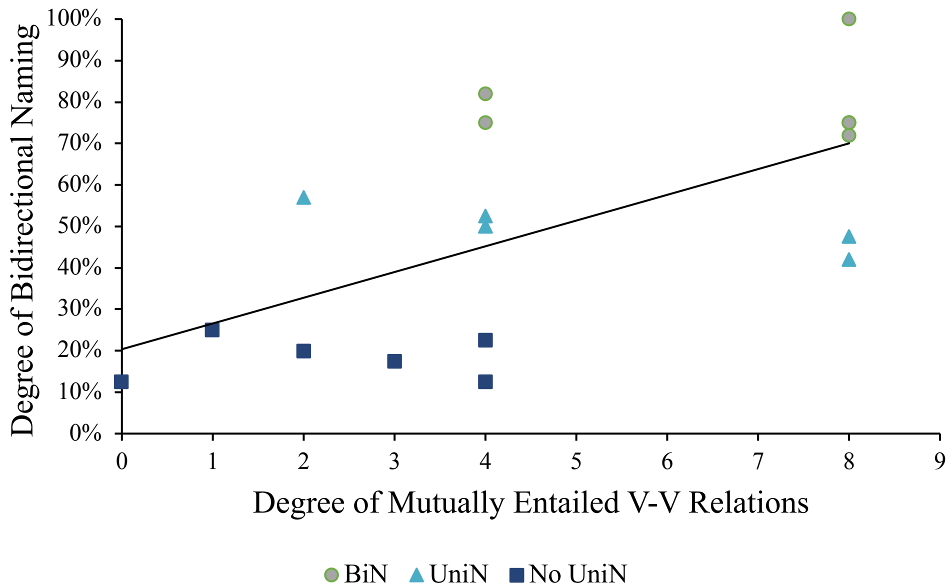


Figure 20. The participants' degree of BiN in relation to their establishment of combinatorially entailed visual-visual relations.

The Mean Differences Between Visual-Visual Relations and the Degree of Bidirectional Naming

An ANOVA was run to analyze the mean differences in the establishment of visual-visual relations between the experimental groups. An alpha level of .05 was used to determine the significance of the following analyses. The results of the ANOVA showed that the effect of the participants' degree of Bidirectional Naming on their visual-visual relations was significant, $F(2,15) = 4.107$, $p = .038$. A post hoc using the Bonferroni procedure indicated that the average number of correct responses for students with no or low degree of BiN were significantly lower than students with BiN ($M = -6.16$, $SD = 2.16$, $p = .037$), but were not significantly lower from student with UniN ($M = -3.66$, $SD = 2.16$, $p = .33$). Figure 21 provides a visual display of the participants' mean number of correct visual-visual responses, as related to their level of BiN.

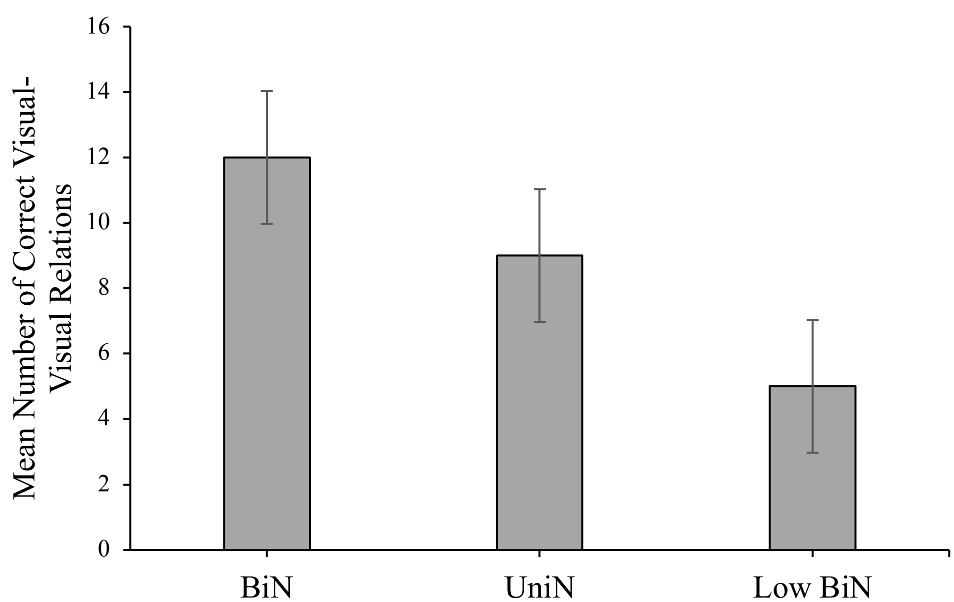


Figure 21. The mean correct responses and standard error for visual-visual relations across all participants.

Discussion

The relationship between Bidirectional Naming and auditory-visual derived relations demonstrated the strongest correlation, suggesting that the presence of Bidirectional Naming aids in an individuals' demonstration of auditory-visual relations or the presence of derived relations aids in BiN. These data also may suggest that there is another underlying variable, which is connected to BiN or derived relations, that affects both variables. In addition, BiN is a measure of mutually entailed frames of coordination and being that half of the responses for auditory relations measured within this experiment were mutually entailed frames of coordination it may be stated that these responses are a different way to measure the same repertoire.

Also, when comparing the means for each experimental group, as related to their demonstration of auditory-visual derived relations, there was a significant difference between participants with low degrees of BiN, and participants with UniN as well as with participants demonstrating the presence of BiN. This finding suggests that the presence of UniN may be the minimum for a participants' acquisition of auditory-visual derived relations. In addition, while assessing the relation between Bidirectional Naming and visual-visual derived relations, there was a moderate correlation which also demonstrates that the presence of Bidirectional Naming is a significant developmental cusp in the acquisition of more complex derived relations. Further analysis of these data demonstrated that participants with low BiN demonstrated a significantly lower mean of correct responses than participants with BiN; however, there were no significant differences for participants with UniN. This suggests that the joining of listener and speaker repertoires, that occurs during the induction of BiN, may be necessary for an individuals' demonstration of more complex derived relations.

CHAPTER V

GENERAL DISCUSSION

Across two experiments, I analyzed the relations between BiN, derived relations and non-arbitrary relational responses. The purpose of Experiment I was to investigate the relationship between BiN, as demonstrated with unfamiliar and familiar stimuli, and its association with arbitrary and non-arbitrary relational responses; as well as measure the difference in the establishment of derived relations in the presence and absence of a visual stimulus. The findings from this experiment showed significant correlations between BiN and derived relations; more specifically, the strongest relation was demonstrated between BiN with unfamiliar stimuli and arbitrary derived relations.

While the findings from Experiment I demonstrated significant correlations between BiN and the establishment of relational responses, the experiment only measured cross-modal stimulus relations; thus, the purpose of the second experiment was to analyze the correlation between BiN, auditory-visual derived relations, and visual-visual derived relations. The findings from this experiment showed a strong correlation between BiN and cross-modal derived relations and a moderate correlation between BiN and visual-visual derived relations; however, the relation between visual-visual derived relations and BiN were not significant when controlling for Boehm scores suggesting that the overall verbal competence of an individual may be a moderating variable in the relation between BiN and visual-visual derived relations.

Based on the findings across both experiments, I suggest the presence of language repertoires, such as BiN, is a determining factor for the establishment of cross-modal derived relations that include an auditory stimulus. These results are consistent with research suggesting that an individual's verbal behavior influences their establishment of derived relations (Kobari-Wright & Miguel, 2014; Miguel & Kobari-Wright, 2013; Miguel, Petursdottir, Carr, & Micheal, 2008; Lee et al., 2015).

Patterns of Correlations

In the first experiment, the participant's degree of BiN with familiar and unfamiliar stimuli was analyzed in relation to their establishment of derived relations. The analysis between BiN with familiar stimuli and derived relations yielded no significant correlations, while the analysis between BiN with unfamiliar stimuli demonstrated strong positive correlations. This is consistent with recent research in VBDT that suggests that an individual's demonstration of BiN may be dependent upon the stimuli used, in that individuals typically demonstrate a lower degree of BiN with unfamiliar stimuli (Lo, 2016). Similarly, the analysis between non-arbitrary relations and BiN yielded no significant correlations, while the analysis between arbitrary relations and BiN demonstrated strong significant correlations. This finding is consistent with research in RFT that suggests that arbitrary relations are more complex because these relations are made based on verbal contextual cues rather than the formal characteristics of the stimuli (Hayes et al., 2001). One possible rationale for this pattern is that participants may have generalized stimuli with shared formal characteristics, thereby leading to higher correct responses which were not due to derived relations but rather generalization. When considering both of these findings, there seems to emerge a pattern between more complex displays of these repertoires. Thus, these patterns may be present because the relationship between BiN and derived relations may only be discernable with higher level manifestations of these repertoires.

In addition, across both experiments, there was a pattern of stronger correlations between BiN and mutually entailed relations. These data may suggest that BiN and mutually entailed derived relations are foundationally the same concept, and thus they are different ways to measure one repertoire. Moreover, there was a consistent split between combinatorially entailed responses, with participants either demonstrating very low responses or criterion level responses. When further analyzing these data only participants demonstrating either Unidirectional Naming or Bidirectional Naming demonstrated combinatorially entailed responses. These findings suggest that BiN and mutual entailment may be predictive of combinatorial entailment.

The Role of the Visual Stimulus

The role of the visual stimulus was analyzed through examining the difference between the participants' establishment of derived relations, as demonstrated through their emission of intraverbal tact and intraverbal responses. While the intraverbal tact involved the presentation of a visual stimulus, the intraverbal responses consisted of only a vocal antecedent. The analysis between these two responses demonstrated no significant difference between the participants' demonstration of intraverbal tact or intraverbal responses; and thus, if they emitted correct responses in one repertoire, they also demonstrated correct responses in the other repertoire. These data demonstrated that the presentation of the stimulus did not affect their demonstration of derived relations. I believe that these data may be attributed to the participants' conditioned seeing repertoire (i.e., their capability to visualize the stimulus, or other stimuli within the same class, after hearing the tact). Thus, a student who demonstrates conditioned seeing will visualize the target stimulus and other stimuli that have been related to this stimulus through a history of reinforcement, thereby producing the name for these stimuli in either condition; while a student that does not demonstrate conditioned seeing will have more trouble visualizing the stimuli within the stimulus class and thus will additionally have trouble emitting the tact for these stimuli in both conditions. Moreover, it has been demonstrated that an individual's demonstration of conditioning seeing is related to their degree of BiN (Shanman, 2013), thus, conditioned seeing could also be an essential underlying variable for the establishment of arbitrary derived relations.

Cross-Modal Relations Versus Relations Within One Stimulus Modality

The literature on the establishment of derived relations often suggests that individuals more readily demonstrate relations that are cross-modal (Arntzen, 2004; Arntzen & Lian, 2010; Holth & Arntzen, 1998). While the first experiment demonstrated a relation between BiN and derived relations, the responses measured for both repertoires were cross-modal; and thus, the second experiment attempted to delve further into these repertoires by including visual-visual derived relations. The findings from Experiment II for BiN demonstrated a strong significant correlation between auditory-visual derived relations and a moderate correlation between visual-visual derived relations. However, when controlling for the participants' Boehm scores the relation between visual-visual derived relations and BiN was no longer significant. This finding may first suggest that BiN is more closely related to derived relations that involve two or more stimulus modalities. Secondly, this finding may suggest that an individual's verbal repertoires may be the underlying variable or a determining factor for their establishment of derived relations (Kobari-Wright & Miguel, 2014; Lee et al., 2015; Miguel & Kobari-Wright, 2013; Miguel et al., 2008). Finally, being that auditory-visual derived relations more closely mirror typical language experiences (Hayes et al., 2001), BiN may be more significantly correlated with auditory-visual relations because these relations demonstrate responses that are more verbal.

Educational Implications

The findings from this study add to the current scholarship that discusses how the establishment of untaught relations may be related to an individuals' underlying verbal repertoire. More specifically, the data from these experiments suggest that BiN, or other speaker-as-own-listener repertoires, may be the precursor to the establishment of derived relations; which also suggests that the induction of new reinforcers, which occurs in the induction of BiN, also affects an individual's demonstration of derived relation repertoires. Thereby having implications on the way we induce derived relations and the way that we learn prior to the induction of BiN.

The induction of derived relation repertoires has been demonstrated having overall beneficial effects in intelligence quotient (Cassidy & Roche, 2011; Vizcaino-Torres et al., 2015), overall demonstration of verbal repertoires, and the strengthening of relational networks (Fox, 2004). Being that the presence of derived relation repertoires has the above-mentioned positive effects, research on the induction of derived relation repertoires is essential for all children with varying levels of verbal behavior. Research on untaught stimulus relations have employed SEI (Kobari-Wright & Miguel, 2014; Lee et al., 2015; Lowe, C.F., Horne, P. J., Harris, F. D. A., & Randle, V. R. L., 2002), MET (Barnes-Holmes et al., 2001; Rosales et al., 2011), and Relational Completion Procedure (RCP) (Dymond & Whelan, 2010). Thus, the findings discussed within this study may reveal other alternate ways that derived relations may be acquired for preschool students with and without developmental delays.

In addition, empirical research on BiN has demonstrated notable changes in an individual's learning, following its acquisition. With the emergence of BiN, individuals demonstrate acceleration of the incidental acquisition of words through the use instructional demonstration learn units (Greer et al., 2011; Hranchuk, 2011). Proponents of the VBDT postulate that these changes are due to the acquisition of conditioned reinforcement for observing responses, which is theorized as the source of reinforcement for the demonstration of BiN (Longano & Greer, 2015). The data from the current experiments demonstrated a strong association between BiN and derived relations. The addition of this new finding along with the current research on BiN and derived relations results in some implications on the way that individuals may be taught following their induction of BiN. Based on the associations demonstrated in this experiment, children with BIN may also demonstrate a heightened understanding of metaphors, greater demonstrations of problem-solving, and stronger relational networks within their syntax.

Limitations

One limitation, in Experiment I, was the lack of a method to control for the participants' level of familiarity with the stimuli. Therefore, some of the stimuli may have been more familiar for some participants while unfamiliar for other participants; for example, the dog stimuli used might have been more familiar for participants with a dog and unfamiliar for participants that have little experiences with dogs. Also, all of the unfamiliar stimuli were given contrived one syllable names while the unfamiliar stimuli had one-two syllable names; this syllabic difference in the names for the stimuli may have skewed the data for BiN across familiar and unfamiliar stimuli.

Also, comparatively the sample sizes used in Experiment I and Experiment II were small when measured against some other typical group analyses. Further, the derived relation teaching procedures used in Experiment I required participants to complete listener training before a probe for their establishment of derived relations. Being that some of the participants demonstrated the need for a tactic, as determined through an analysis of their graphical data using the decision protocol (Keohane & Greer, 2005), a probe was not conducted for some relations, and thus these participants were dropped out of the analysis. By reducing the participant sample, the power of the analyses was also reduced, and the findings of these experiments may have been skewed to portray stronger significant relations. Also, in reducing the sample size, the analyses were confined to higher functioning students, as defined by their degree of Bidirectional Naming; thus, affecting the external validity of this paper and the generalization of these findings to students with lower degrees of Bidirectional Naming.

Another limitation is that for both experiments only frames of coordination were measured due to the age range of the participant sample. However, this negatively affects the external validity of these findings by making it more difficult to generalize these findings to different derived relations and different groups of older students.

Finally, for Experiment I and II there were a low number of listener responses assessed for derived relations, and thus there were not enough data to complete any analyses between listener and speaker responses.

Future Research

Due to the limitations described above, future research should analyze the relation between BiN and different relational frames for students with a broader range of BiN. Using participants that have more of a range in their degree of BiN will help improve the external validity of these findings by demonstrating whether the results may generalize to students with different levels of verbal behavior. Also, assessing additional relational frames will help to support these claims in showing that the relation is not only present with frames of coordination but with a variety of other frames.

The findings from Experiment I demonstrated that there was no statistically significant difference between the participants' demonstration of intraverbal tact and intraverbal responses; further the data demonstrated that if the participants demonstrated the emission of correct responses in one repertoire they demonstrated the responses in the remaining repertoire, which suggest that the presentation of the visual stimulus does not play a significant role in an individuals' establishment of derived relations. However, one repertoire I believe is necessary for the emission of both intraverbal tact and intraverbal responses is conditioned seeing. This repertoire may be a foundational pre-requisite from which both of these repertoires are based, being that both repertoires require the participant to visualize the other stimuli within the stimulus class presented. Therefore, further research should be conducted on the participants' demonstration of conditioned seeing repertoires in relation to their establishment of derived relations.

Empirical research in derived relations suggests that individuals often acquire derived relations more efficiently and effectively when they include familiar picture stimuli and are across different stimulus modalities (Arntzen, 2004; Arntzen & Lian, 2010; Holth & Arntzen, 1998). While cross-modal relations have been more efficiently and effectively demonstrated, the emergence of within sensorial-modality equivalence has been demonstrated (Belanich & Fields, 1999; Green, 1990; Sidman, 1994). These relations have been used as an argument against language being a determining factor in the establishment of stimulus relations because these conditional relations do not utilize the tact repertoire (Williams & Jackson, 2009). Thus, additional experiments manipulating these variables will provide further information on the kinds of relations that are more closely related to the individuals' demonstration of language. These experiments will also add more information on the type of derived relations (i.e., either across or within stimulus modalities) that is more significantly related to BiN.

The results of the first and second experiment demonstrated moderate to strong correlations between BiN and auditory-visual derived relations. More specifically, the results demonstrated that as correct responding in one repertoire increased the same occurred in the other repertoire, which makes several suggestions for the relationship between BiN and derived relations. The first suggestion is the establishment of BiN as the source of auditory-visual derived relations, which would be consistent with literature that states the establishment of stimulus relations is dependent upon an individual’s verbal repertoires (Kobari-Wright & Miguel, 2014; Lee et al., 2015; Miguel & Kobari-Wright, 2013; Miguel et al., 2008). The second suggestion is conditioned reinforcement for observing responses as the source of reinforcement for both BiN and derived relations; and therefore, this finding would suggest that rather than one repertoire being the precursor for the other repertoire, it may be that both repertoires are affected by the same reinforcers. Thus, because VBDT pinpoints conditioned reinforcement for observing responses as the source of reinforcement for BiN, this may suggest MEI as an effective strategy for inducing both repertoires because it establishes the necessary reinforcers. The same underlying source of reinforcement may also suggest that the induction of derived relation could also result in the acquisition of BiN. However, additional research needs to be conducted to analyze the source of reinforcement for these repertoires further. Therefore, I think the next step should be a single case design that systematically induces one variable and then measures these effects on the remaining variable. These data would show whether one repertoire is a precursor for the other, or whether both behaviors symbiotically affect each other and are thus related to other underlying variables verbal repertoires.

Conclusion

The results of these experiments add to the conversation on the interactions between a child's verbal repertoires and their establishment of stimulus relations. In Experiment I, the degree of BIN and the establishment of arbitrary and non-arbitrary relations were measured to analyze the association between these variables. The results demonstrated a strong correlation between BiN with unfamiliar stimuli and cross-modal derived relations. Thus, the second experiment was conducted to test the relations between the participants' degree of BiN and their demonstration of auditory-visual and visual-visual derived relations. These results demonstrated a stronger correlation between cross-modal relations and BiN with unfamiliar stimuli, suggesting that BiN is more closely related to "verbal" derived relations or relations that involve auditory and visual stimulus modalities. This research has implication for the source of derived relations either being BiN or conditioned reinforcement for observing responses. Furthermore, previous empirical research has demonstrated that when children have Bidirectional Naming, they learn at different rates and through different instruction. This research adds to this literature by discussing other repertoires that may be established with the induction of BiN and derived relations. Therefore, this research has implication for the way that an individual's verbal repertoire can aide in the establishment of cross-modal stimulus relations and their degree of BiN and thus change the way they learn.

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