Degrees of Bidirectional Naming Are Related to Derived Listener and Speaker Responses

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ABSTRACT

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Incidental language acquisition has been a topic of interest in the field of education, cognitive psychology, and behavior analysis (Horne & Lowe, 1996; Carey & Bartlett, 1978; Greer & Speckman, 2009). Researchers in the area of verbal behavior and derived relations have developed multiple perspectives that overlap in many ways (Greer & Ross, 2008; Greer & Speckman, 2009; Hayes, Barnes-Holmes, and Roche, 2001). Despite the overlap of these perspectives, research to date has been conducted independently. Fienup (2019) acknowledges the overlap in the respective work and suggest that integration can produce a more cohesive and comprehensive understanding of the development of verbal behavior. Study 1 included two experiments. In Experiment 1, the experimenter exposed 14 preschoolers with varying degrees of bidirectional naming (3 classified as having bidirectional naming (BiN), 8 as having unidirectional naming (UniN), and 3 as having no incidental naming (NiN) to two conditions, 1) directly reinforcing speaker (tact) responses and testing for the emergence of listener (point to) responses, and 2) directly reinforcing listener responses and testing for the emergence of speaker responses. The experimenter rotated between two conditions. Results suggested that participants with BiN readily derived speaker and listener responses, participants with unidirectional naming (UniN) readily derived listener, but not speaker responses, and participants with NiN had difficulty acquiring directly reinforced responses and deriving responses. In Study 1 Experiment 2, six participants with unidirectional naming (UniN) were selected from Experiment 1. Multiple

Exemplar Instruction (MEI) and stimulus-stimulus pairing procedures were implemented to induce the capability of BiN. Following the acquisition of BiN, the experimenter replicated the repeated measure design of directly reinforcing speaker or listener responses and testing for the emergence of corresponding responses. Upon the acquisition of BiN, participants derived both listener and speaker relations, suggesting that the development from UniN to BiN is associated with the stimulus control for speaker responses following direct reinforcement for listener responses. Study 2 addressed the limitations of Study 1 and replicated the procedures with new participants and new science educational content. The experimenter selected 6 participants that demonstrated BiN and 5 that demonstrated UniN. Data support the findings of Study 1, suggesting that degrees of bidirectional naming are associated with degrees of derived relational responding.

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DEDICATION

To my loving parents Naima and Aleem Ghany,

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CHAPTER 1: Overview of Concepts and Theoretical Frameworks

An accumulation of research has been dedicated to the study of language acquisition, as language is a strong predictor of overall outcomes (Frampton, Robinson, Conine, and Delfs, 2017). Typically developing children are known to experience a language explosion and acquire a vast vocabulary at a substantial rate around the age of three (Hart and Risely, 1995). Different perspectives in behavioral science have attempted to account for factors that influence this “language explosion”. Stimulus Equivalence (SE), Relational Frame Theory (RFT), and Naming are all accounts that bear on language development. While different in focus, the three accounts share a common theme that the extensive vocabularies that children acquire cannot only be attributed to direct instruction (Greer & Ross, 2008; Sidman, 1994; Hayes, Barnes-Holmes, & Roche, 2001). Therefore, these researchers have spent the last 60 years extending upon Skinner’s Verbal Behavior (1957) research to understand how one acquires language incidentally from his or her environment.

1.1 Stimulus Equivalence (SE)

Sidman (1994) sought to explain the emergence of novel and topographically distinct responses via mathematical set theory. Sidman’s early worked focused on reading comprehension (Sidman, 1994; Sidman, 1971; Sidman & Cresson,1973), but later became a broader model that could be used to predict and explain language acquisition. Equivalence classes are sets of physically disparate stimuli that demonstrate the properties of reflexivity, symmetry, and transitivity, which provide an empirical method of studying the emergence of novel stimulus-stimulus relation, novel behaviors, and language acquisition. Reflexivity (A=A) is said to occur when a stimulus bears a relation to itself, for example matching a picture of cat to an identical picture of cat (also called identity matching). Symmetry (A=B, B=A) is a bidirectional relation between stimuli when only one direction of the relation is directly reinforced (e.g., when a student is taught to point to the word cat, after the vocal response of "cat" or vice versa). Transitive relations are demonstrated when two stimulus-stimulus relations are trained (if A=B and B=C, then A=C) and result in the emergence of a third untaught relation. Specifically, the first relations are taught between an initial stimulus (A) and a secondary stimulus (B), followed by the teaching of a second relation between the secondary stimulus (B) and a novel stimulus (C). As a result, a student can derive a third relation incidentally without direct instruction between the initial stimulus (A) and the novel stimulus (C) (Sidman & Tailby, 1982).

According to Sidman (1994), when a set of 3 or more stimuli demonstrate the aforementioned properties (reflexivity, symmetry, and transitivity), those stimuli are said to be equivalence classes. This paradigm has been applied to teach a variety of populations different educationally relevant equivalence classes, including college students learning about single subject research designs (Lovett, Rehfeldt, Garcia, & Dunning, 2011) and neuroanatomy (Fienup, Mylan, Brodsky, & Pytte, 2016). Other populations, such as students diagnosed with Autism Spectrum Disorder (ASD) or developmental delays were taught coin equivalences (Keintz, Miguel, Kao & Finn, 2011), and United States geography (LeBlanc, Miguel, Cummings, Goldsmith & Carr, 2003). Collectively, the research has shown the effectiveness of engineering derived stimulus relations with various populations, content areas, and methods that facilitate emergent learning (for reviews, see Brodsky & Fienup, 2018; Rehfeldt, 2011).

1.2 Relational Frame Theory

Sidman's focus on derived relations between stimuli that are symbolically related by sameness was elaborated on by Hayes, Barnes-Holmes and Roche (2001) to include multiple contextual variables that can control the relation between two stimuli, such as being opposites or hierarchically related. There are many ways that stimulus events can be related, as a relational frame is both an outcome and process concept (Hayes et al., 2001). The expansion of the model to include non-equivalence relatedness necessitated re-terming derived relations to be more flexible. Given the breadth of the theory, only a few concepts will be highlighted and expanded upon in terms of relations and frames. Mutual entailment is a relation that describes one direction that has been directly taught in a bidirectional relation. For example, if the learner is directly taught that $5 is more than $1, then the reverse relation can be derived that $1 is less than $5 because not all derived relations are the same. It is important to note that in the case of symmetry all relations are mutually entailed but not all mutual entailed relations are symmetry (Critchfield & Rehfedlt, 2019). Combinatorial entailment is another relation that links two stimuli that are mutually entailed and share a single stimulus. For example, the word pretty is synonymous with beautiful (i.e., they are mutually entailed) but both are the opposite of ugly; thus, if one learned pretty = beautiful and beautiful is the opposite of ugly, one may derive that pretty is also the opposite of ugly via combinatorial entailment. Similar to mutual entailment and symmetry, combinatorial entailment can be used to describe transitive relations but not all combinatorial entailment is transitivity (Critchfield & Rehfeldt, 2019).

Another major concept that extends the SE approach and defines RFT is the introduction of frames. Frames are used to describe the various relations (e.g., opposite of, more than, different from etc.) The frame of coordination is the most fundamental type of relational responding and it establishes equivalence classes (i.e. stimulus A is the same as stimulus B), this is typically seen in Match-to-sample (MTS) instruction. The frame of opposition specifies the dimension that the frame can be ordered and point of relevance (e.g., “beautiful is the opposite of ugly”). A third relational frame is a frame of distinction, this involves responding to one event in terms of another, but with no specificity. For example, if one is told that the weather outside is not warm, one cannot discern whether the weather is hot or cold due to a lack of reference point. Comparative frames are used when events are described in terms of a quantitative/qualitative relation along a specified dimension with another event. For example, a cat is twice as fast as mouse (mutual entailment) and mouse is twice as fast as an ant (mutual entailment), the two mutually entailed relations involving the mouse give rise to a combinatorial entailed relation that the cat is four times faster than the ant. In regard to “other” relations aside from equivalence, RFT expounds that one can derive numerous relations of correspondence, distinction, comparison, opposition and many more between endless stimuli, and experiences. Hayes et al. (2001) mention a plethora of frames, which are beyond the scope of this discussion.

Hayes et al.’s (2001) Relational Frame Theory (RFT) elaborates on the properties proposed by Sidman (1994) and adds transformation of stimulus function (TSF). This phenomenon explains how behavioral functions (discriminative properties, conditioned reinforcement, elicitation of emotions, etc.) of one stimulus transform to other stimuli that become related. Even when a group of stimuli are said to be equivalent, then each can be interchangeable with any other. It is in accordance with the contextually controlled frames. For example, if A is a conditioned reinforcer and it is mutually entailed via a frame of coordination with B, then B inherits the same conditioned reinforcer function. If it is mutually entailed via a frame of opposition to B, B becomes a conditioned punisher. Hierarchically, it becomes more or less reinforcing (depends on hierarchy) (Hayes et al, 2001; Pilgrim, 2020).

These relations are explained in terms of frames and attribute to how one learns word-meaning relations (Hayes et al., 2001). Furthermore, these relational frames demonstrate contextually controlled and arbitrarily applicable properties and with exposure to Multiple Exemplar Instruction (MEI) and operant conditioning can become generalized operants (Healy, Barnes-Holmes, & Smeet, 2000). Research from Greer and his colleagues suggest that MEI refers to the rotation of response topographies, specifically, point, tact, and match (Greer &Yuan, 2005) or across vocal spelling and writing (Greer, Stolfi, Chavez-Brown, & Rivera-Vales, 2005). Similar to stimulus equivalence research that have produced robust experimental evidence for the effectiveness of designing various populations and content areas (Fienup & Brodsky, 2018). RFT expands on the scope of instruction and incorporates these frames beyond language that led to the successful development of Acceptance and Commitment Therapy (ACT) for the treatment of a wider variety of mental health and addiction conditions (Hayes, Luoma, Bond, Masuda, & Lillis, 2006; Powers, Zum Vorde Sive Vording, & Emmelkamp, 2009; Hayes, 2004).

1.3 Naming Theory

Decades of research allude to Naming as a prerequisite skill in derived relational responding. Naming focuses on the contingencies that generate the coordination of listener and speaker repertoires that may be necessary for the capacity to derive equivalence classes (Luciano, Bederra, & Valverde, 2007; Horne & Lowe, 1996). Horne and Lowe (1996) sought to explain how an individual learns listener and speaker responses incidentally without direct instruction through the Naming theory. They proposed the interdependence of both listener and speaker behavior, as the relationship between the listener and speaker repertoires become more complex it is important to explicitly define each. Listener behavior, sometimes referred to as conditional discrimination, includes orienting, using various simple discriminations, or emitting a selection response etc. (Sprinkle & Miguel, 2012; Frampton et al., 2017). In contrast, speaker behavior (i.e., tacts) teaches the child to label/state the name of a common object (Frampton et al.2017).

As a child's verbal repertoire becomes more complex there is the joining of the listener and the speaker, or listener-as-own speaker (Lodhi & Greer, 1989). Lowenkron (1997) suggested that the joining of these repertoires was a function of an instructional history of differential reinforcement for multiple exemplar experiences. Joint stimulus control, in which one stimulus controls multiple responses results from a history of multiple experiences and the emergence of the untaught responses (Greer, Stolfi, Chavez-Brown, & Rivera-Valdez, 2005). A large body of research provides experimental evidence suggesting that mixing listener and speaker instructional trials (multiple exemplar instruction; MEI) can result in the induction of bidirectional relation capability of Bidirectional Naming (BiN) (Fiorile & Greer, 2007; Greer, Stolfi, Chavez-Brown & Rivera-Valdes, 2005; Greer, Stolfi, Pisoljevic, 2007; Longano & Greer, 2010; LaFrance & Tarbox, 2019). BiN is a capability that allows a student's behavior to come in contact with new contingencies and they can learn in new ways. Catania (1998) defines Naming as a higher-order operant that allows an individual to learn a response incidentally after being directly taught in a different response topography for the same stimulus.

1.4 Verbal Behavior Developmental Theory (VBDT)

While Horne and Lowe are the seminal reference for this indispensable capability and attribute immense research to the development of one's verbal behavior, Greer and Speckman (2009) and Greer and Ross (2008) incorporate Naming in the Verbal Behavior Developmental

Theory (VBDT) and deem it to be a behavior developmental cusp (Rosales-Ruiz & Baer, 1996) and/or learning capability (Greer & Speckman 2009; Greer, Pohl, Du, & Moschella, 2017).

Greer and colleagues extended on previous literature and have proposed a developmental trajectory of one's verbal behavior through the Verbal Behavior Developmental Theory (VBDT) (Greer & Speckman, 2009; Greer & Ross, 2008). VBDT highlights that development is not a linear progression but rather an accumulation of interrelated cusps and cusps that are new learning capabilities. A paramount contribution to behavioral treatment was the notion of behavioral developmental cusps (Rosales-Ruiz & Baer, 1996). VBDT argues that when children learn the pre-verbal repertoires early in life, it leads to acquisition of listener cusps, speaker cusps, and eventually the joining of the listener and speaker to become truly verbal. Each milestone consists of repertoires that the VBDT deems to be either a verbal developmental cusp (Rosales-Ruiz & Baer, 1986) and some cusps that are new learning capabilities (Greer & Speckman, 2009). The induction of these cusps can allow for one to contact new reinforcing or punishing environmental contingencies or the result of newly conditioned reinforcers. Acquisition of one developmental milestone that provides the potential for others, thus emphasizing the importance of acquisition of each behavioral cusps or capability.

The capability of bidirectional naming (BiN) is associated with the emergence of untaught relations as in the case of a student learning a speaker response (i.e. tact response) and then emitting the untaught topography of a listener response, such as pointing to the stimulus for the tact stimuli (Lowe, Horne, Harris, & Randle, 2002). Greer et al. (2017) compares this behavioral transformation to that of metamorphosis in biology. Each stage of verbal development can be compared to the metamorphosis of a butterfly. The egg represents the pre-verbal foundational cusps that a child acquires such as, orienting to voices, faces, and generalized identity matching. The next two phases represent the independent listener and speaker stages. The final stage shows the joining of the listener and the speaker, and demonstrates the child becoming truly verbal. Once a child acquires the necessary cusps and capabilities of becoming truly verbal, they now can access different contingencies in the environment, thus allowing them to fly.

1.5 Integration of Verbal Behavior

Having examined various theories and perspectives of language acquisition, the question remains can we integrate and move beyond these individual perspectives of language? A challenge in integrating the findings and theories of multiple camps in behavior analysis, are the variations that exists among their terminologies. The present study intended on describing, three different camps of verbal behavior: (a) Stimulus equivalence (SE), (b) Relational Frame Theory (RFT) and (c) Naming/ Verbal Behavior Developmental Theory (VBDT). Although research surrounding these theories may describe an identical phenomenon, the deviations of the terminology easily create the impression of contrary meanings (Fienup, 2019).

General Aims

The purpose of the research is to contribute to the understanding of incidental language acquisition and basic relational concepts by incorporating procedures developed by different camps within behavior analysis and examining how different dependent variables map onto each other. Stimulus Equivalence (Sidman, 1994), Relational Frame Theory (Hayes & Barnes-Holmes & Roche, 2002) and the Naming theory (Horne & Lowe, 1996) demonstrate various similarities across incidental language acquisition. All three theories are extensions of Skinner's (1957) theory of verbal behavior and seek to explain how language is learned incidentally; they all demonstrate some form of bidirectional capability (bidirectional naming, symmetry, mutual entailment) and employ multiple exemplar instruction to test for and induce these indispensable phenomena. The study of derived relations has been a growing field that has produced a fruitful body of research and application, that correlate with the aforementioned theories (Miguel & Petursdottir, 2011). In regard to relations aside from equivalence, RFT explain that one can derive numerous relations of correspondence, distinction, comparison, opposition, experiences, beliefs etc. These relations are explained in terms of frames and attribute to how one learns word-meaning relations (Hayes et al. 2002). Furthermore, these relational frames demonstrate contextually controlled and arbitrarily applicable properties, and with exposure to MEI and operant conditioning can become generalized operants (Healy, Barnes-Holmes, & Smeet, 2000). These relational frames result in the production of derived relational responding; which allow a student to become truly verbal.

Study 1 contained two experiments. The aims of Study 1 are as follows:

1. How do students with varying degrees of BiN (i.e. NiN, UniN, and BiN) differ in derived relational responding?

2. How can teachers differentiate instruction (i.e. listener training v. speaker training) to produce efficient learning, based on a student's cusps and capabilities?

The aims of Study 2 are as follows:

3. Replicate the findings from Study 1 while addressing the limitations and changing the educational content.

Study 1 Experiment 1 compared students with various levels of verbal behavior (i.e. bidirectional naming, unidirectional naming, and no incidental naming) and assess whether there is a relation between the presence of each and derived relational responding. Study 1 Experiment 2 investigated the establishment of BiN and examined how the student's derived relational responding (emergent speaker and listener responses) changed as a function of acquiring this developmental capability. A repeated measure within-subjects design was be used, where each participant will serve as their own control and will be compared under the speaker and listener protocol conditions before and after the acquisition of the BiN capability. The current research suggests that participants with UniN are able to derive the untaught listener responses following the acquisition of speaker responses, but not the reverse. Whereas, students with BiN acquired these relational responses, regardless of the training topography. Recent evidence suggests that bidirectional naming relations may be facilitating derived relational responding (Miguel & Petursdottir, 2009). Study 2 addressed the limitations of Experiment 1 and further evaluated the emergence of equivalence class formations with different educational content.

Organization of Dissertation

This chapter provided an outline of the studies and its applied and basic application of derived relational responding, equivalence-based instruction (EBI) and bidirectional naming. The following two chapters present two different studies that comprise the dissertation. Study 1 (i.e. Chapter 2) was comprised of two experiments that examine the correlation between the degree of bidirectional naming and derived relations. Study 2 (Chapter 3) addressed the limitations of the first study, and further derived relations and bidirectional naming. A general discussion is provided in Chapter 4, which discusses how the current study addressed some of the missing links in the present literature.

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Chapter 2: A Preliminary Analysis of Bidirectional Naming and Derived Listener and Speaker Responses

Abstract

As a child develops new cusps and capabilities, their behavior comes in contact with new contingencies and they can learn in new ways. We examined how degrees of bidirectional (BiN) naming correlated with children's derived relations. BiN is the joining of listener and speaker repertoires such that hearing object-name relations produces corresponding speaker and listener behavior. Unidirectional naming (UniN) occurs when this experience produces listener, but not speaker behavior. Students who did not demonstrate listener and speaker components of were classified as having No Incidental Naming (NiN). In counterbalanced ABAB within-subjects design we rotated between two conditions: 1) directly reinforcing speaker (tact) responses and testing for the emergence of listener (point to) responses, and 2) directly reinforcing listener responses and testing for the emergence of speaker responses. Results suggested that participants with BiN readily derived speaker and listener responses, participants with UniN readily derived listener, but not speaker responses, and participants with NiN had difficulty acquiring directly reinforced responses and deriving responses. Our results suggest ways to incorporate derived relations instruction and differentiate instruction for children with different capabilities and have implications for the overlap between verbal behavior and derived relations research areas.

Keywords: bidirectional naming, derived relations, unidirectional naming

A Preliminary Analysis of Bidirectional Naming and Derived Listener and Speaker Responses

As a child develops new developmental capabilities, their behavior comes in contact with new contingencies and they can learn in new ways. This allows educators to differentiate instruction based on the learner's repertoires in order to produce efficient learning. A system of instruction that capitalizes on efficiency is a curriculum that programs for derived relations, or emergent responding (Pilgirm, 2020; Stromer, Mackay, & Stoddard, 1992). The practical implications of emergent learning are vast and accounts for responding to an event in terms of another, even when that correspondence was not directly taught. These responses can be taught, where organisms learn to respond relationally in a manner that focuses on the relation between stimuli rather than their physical properties (Luciano, Rodriguez, Manas & Ruiz, 2009). Decades of research have investigated the emergence of novel or derived responding (Barnes-Holmes, Smeets, Cullin & Leader, 2004; Sidman, 1994; Rehfeldt, 2011).

The potential of programming for the emergence of derived relations can be seen in early investigations. For example, Sidman and Cresson (1973) used an equivalence framework to teach reading comprehension in adolescents with severe intellectual disabilities. The researchers directly reinforced identity matching with printed words, spoken word to picture relations, and spoken word to printed word relations. This training, which mediated a relation between pictures and printed words via spoken words, resulted in the participants deriving relations between pictures and printed words, thus demonstrating reading comprehension. This paradigm has been applied to a number of different academic concepts (see reviews by Brodsky & Fienup, 2018; Raaymakers, Garcia, Cunningham, Krank, & Nemer-Kaiser, 2019; Rehfeldt, 2011), even more basic research, and has been elaborated upon to consider different types of relational control between stimuli (Critchfield & Rehfeldt, 2020; Hayes et al., 2001)

This phenomenon has also been evaluated by researchers from a verbal behavior perspective that focuses on speaker and listener behavior and the emergence of additional listener and speaker responses, respectively. Listener trainings are those that target gestural responses (sometimes called receptive responses or conditional discriminations), as is observed when a child matches stimuli or points to a stimulus in a field of exemplars and non-exemplars. Speaker trainings are those that target vocal responses, such as tacting an object. Researchers have examined how the acquisition of one topography of responses produces, without further training, the other topography of responses. For instance, Lee, Miguel, Darcy and Jennings (2015) found that children with Autism Spectrum Disorder (ASD) produced a full range of listener responses following training on corresponding speaker responses. A number of studies have investigated similar procedures, demonstrating that the acquisition of speaker responses under direct consequence conditions led to the emergence of listener responses in the absence of direct consequences (Miguel et al, 2013; Miguel, Petursdottir, Carr & Michael, 2008). Sprinkle and Miguel (2012) directly compared listener and speaker trainings and the effects of the respective trainings on emergent responses. The researchers found that both speaker and listener trainings resulted in the formation of stimulus classes, with speaker trainings producing more robust emergent listener responses than listener training producing emergent speaker responses. While there is some variation in the literature, for example, one study found no emergent behavior regardless of speaker and listener trainings (Petursdottir, Carr, Lechago, & Almason, 2008), reviews of the aggregate literature have led researchers to suggest that instructors should teach speaker responses first, test for the emergence of corresponding listener responses, and only directly teach listener responses if they do not emerge in the absence of direct reinforcement (Contreras, Cooper, & Khang, 2019; Petursdottir & Carr, 2011)

While these suggestions are clear, additional research is needed to clarify the characteristics or repertoires a child brings to the table that influences the emergence of listener and speaker responses. Comparing studies than observed the emergence of untaught responding (e.g., Miguel et al, 2013) to studies that did not observe such emergence (e.g., Petursdottir et al., 2008), it is unknown whether participant variables played a role in the outcomes.

One repertoire that has been conceptually linked to derived relations is bidirectional naming (originally termed Naming by Horne & Lowe, 1996; more recently re-termed bidirectional naming by Miguel [2016] and Greer, Pohl, Du, and Moschella [2017]). Originally, Horne and Lowe (1996) define 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). Thus, the capability of Naming is associated with the emergence of untaught relations as in the case of a student learning a speaker response (i.e. tact response) and then able to emit the untaught topography of a listener response, such as pointing to the stimulus for the tact stimuli (Lowe, Horne, Harris, & Randle, 2002). Horne and Lowe (1996) further suggests that naming (i.e., BiN) can be demonstrated in two ways. The first occurs when one directly teaches one repertoire (listener or speaker responses) and testes for the emergence of the other. The second, more stringent test, is to expose participants to models of word-object relations and test for the emergence of listener and speaker behavior.

The capability of forming stimulus classes and deriving listener and speaker relations are correlated to students’ degree of naming (Eikeseth & Smith, 1992). Miguel (2018) defines the term, bidirectional Naming (BiN) as the integration of both listener and speaker behaviors that lead speaking with meaning and listening to understanding. Once this capability is established, it extends across responses allowing students to learn incidentally (Greer, Corwin & Buttigeg, 2011).

The purpose of this study was to investigate the intersection of bidirectional naming repertoires and one's capacity to derive speaker and listener responses. It examines the dependent variables used across various behavioral camps. The outcomes have implications for how to differentiate instruction and capitalize on derived relations curricula as a function of the developmental repertoires, or cusps, that an individual possesses. In Experiment 1, we exposed participants to speaker and listener protocols and tests of derived relations, similar to the study conducted by Sprinkle and Miguel (2012). In the speaker protocol, we directly reinforced speaker (tact) responses and tested for the emergence of listener responses (point to conditional discriminations) under conditions of no reinforcement. In the listener protocol, we directly reinforced listener responses and tested for the emergence of speaker responses. We recruited participants whose performances varied across the spectrum on bidirectional naming performances. Specifically, we assessed children who engaged in both listener and speaker responses following the observation of name-object relations (bidirectional naming, BiN), children who engaged in listener but not speaker responses (unidirectional naming, UniN), and children who engaged in no listener or speaker responses (no incidental naming, NiN). In Experiment 2, we induced bidirectional naming with several children who initially demonstrate UniN to examine whether the establishment of bidirectional naming produced corresponding improvements in derived relations akin to those observed in participants in Experiment 1 who already possessed this repertoire (Experiment 1 BiN participants).

EXPERIMENT I

In Experiment 1, we assessed children's bidirectional naming and categorized their capabilities. Next, each participant completed speaker and listener trainings and we tested for the emergence of corresponding listener and speaker responses, respectively. Our analysis focused on the correspondence between bidirectional naming subtypes and derived speaker and listener responses.

Method

Participants

Fourteen preschoolers (11 males) with a mean age of 4.7 (*SD* =.53) years of age at the onset of the study participated in this study. We selected participants due to the presence and absence of the BiN capability in their verbal repertoire (BiN assessment described below). Each participant received educational services at a private behavior analytic preschool utilizing the Comprehensive Application of Behavior Analysis (CABAS®) model (Greer, 2002). At the school, educators determined curricula and assessed the presence of developmental cusps via the Preschool Inventory of Repertoires for Kindergarten (C-PIRK®, Greer & McCorkle, 2009). As per this assessment, all 14 participants demonstrated the pre-requisite repertoires to BiN, including reliably attending to instructors' voices, faces, and instructional stimuli. All students in the study had an Individualized Education Plan (IEP) and were educationally classified as a "preschooler with a disability" and received related services. Half of the participant had attended a behavior analytic Early Intervention (EI) program prior to enrolling in the preschool where this study took place. Included students had a mean learn unit to criterion (i.e. number of trial presentations before meeting an objective) of 232.5 (*SD* = 84.266).

Three participant's performances met the criterion for BiN (criterion on listener and speaker responses). These participants had large verbal repertoires and could vocally mand and tact a variety of items. Each completed academic programming that included reading instruction and beginning-level math skills (e.g., one-to-one correspondence between 1 and 20 and the concept of more or less). Participant BiN-1 was a 4.7.-year-old male and attended school for approximately 2.5 years. Participant BiN-2 was a 3.9-year-old female attended school for approximately 2.0 years. Participant BiN-3 was a 4.4.-year-old male and attended school for approximately 2.5 years.

Eight participant's performances met the criterion for UniN (criterion on listener responses, but not speaker responses). These participants had moderate verbal repertoires and could vocally mand and tact a variety of items. At times, these participants gestured to mand, instead of vocalizing mands in novel situations. Each completed academic programming that included early reading skills (e.g., textually responding to letter name and sound) and beginning-level math skills (e.g., number identification). Participants UniN-1 and UniN- 5 were both 4.8-year-old males who attended school for approximately 2.5 years. Participants UniN-2, UniN-4 were both 4.9-year-old males who school for approximately 2 years. Participants UniN-3 and UniN-7 were both 4.6-year-old males who attended school for approximately 2 years. Participant UniN- 6 was a 4.6-year-old female who attended the school for approximately 1.5 years. Last, participants UniN-8 was a 4.4-year-old male that attended school for approximately 1.5 years.

Three participants did not meet the criterion for speaker or listener incidental language acquisition and were thus deemed as possessing no incidental naming (NiN). All participants could vocally mand and tact 25 or more items. At times, these participants required teacher vocal prompts to help communicate their needs. Each completed academic programming that included pre-reading skills (e.g., textually responding to letter name and sound) and beginning-level math skills (e.g., number identification). Participants NiN-1 and NiN-2 were 3.7 and 4.5-year-old males who attended the school for approximately 6 months and 2.5 years, respectively. Participant NiN-3 was a 3.8-year-old female who attended school for approximately 1.5 years.

Setting and Materials

All sessions were conducted in the participants' respective classrooms. During all sessions, the participant sat next to the researcher at a U-shaped table. During bidirectional naming assessment, the researcher presented a picture of an unknown cartoon character (90's cartoon characters – "Ahh Real Monsters' Grumble, Ickis, Oblina, Zimbo and Krumm) printed on on 7.4 x 10.5 cm index cards.

During the derived relations training and testing sessions, participants learned letter-name-sound classes (e.g., A, "A", "aa") or sight words (e.g., who, pretty, live, etc.). Researchers presented the 3.81 by 3.17 cm stimuli via Microsoft PowerPoint® on a 33.2 cm Macintosh laptop. During each trial, 1 to 3 stimuli were presented in a horizontal array, depending on whether the session was measuring speaker (1 stimulus at a time) or listener responses (3 stimuli simultaneously presented). Sight word instruction was presented in a similar manner, where 1 to 3 stimuli appeared on the screen.

Measurement

The primary dependent variable in this experiment was the accuracy of derived relations. We measured derived relations in accordance with which repertoire was reinforced (i.e., measurement of speaker responses following the listener training protocol and measurement of listener responses following the speaker training protocol). A correct response was one that corresponded to the discriminative stimulus and was emitted within 5 s. For example, during the speaker training protocol, if the discriminative stimulus was a picture of the letter A, tacting the stimulus “A” was considered a correct speaker response. An incorrect response was one that did not correspond to the discriminative stimulus or no response within 5 s. Whereas, during the listener training protocol, if the discriminative stimulus was a field of 3 stimulus (i.e., 2 non-target and 1 target stimuli) and the vocal antecedent of “point to the letter A” was given, pointing to the target stimulus “A” was considered a correct listener response. An incorrect response was one that did not correspond to the target stimulus or no response within 5 s.

Training data were collected using learn unit instruction, (i.e., an interlocking 3-term contingencies; at least two for a teacher and one for the student/learner, Albers & Greer, 1991), where correct responses were reinforced and recorded as a plus (+), and incorrect responses were recorded as a minus (-), and a correction procedure was utilized. The researcher collected data on learn units to criterion across each training protocol. The mean number of learn units to criterion (i.e., LUC) was calculated by adding the total number of learn units presented and divided by the number of objectives achieved. We also calculated learn units to criterion for the two training protocols (listener protocol, speaker protocol).

During letter name and sound instruction, the researcher administered 30 learn units (i.e., learning trials) per session. Half of the trials were letter names and half were letter sounds and this included 5 learn units (i.e., LUs) of each of the three target responses presented in a randomized order. Both topographies (letter names and sounds) were plotted as separate data paths (see Figures 2-4). At the end of each session, correct responses were totaled and graphed as a percentage. In order to calculate the correct percentage, the number of correct LU responses were divided by the total number of LU opportunities presented then converted into a percentage (i.e., 5/15 * 100= 33%).

During sight word instruction, the researcher administered 20 LU (i.e., learning trials) per session, that included four operants with 5 LU opportunities to respond to each operant. Target responses were presented in a randomized order and at the end of the session correct responses were recorded in a similar manner as letter name and sound instruction.

During the bidirectional naming assessment, the untaught topography of point, tact and intraverbal responses were measured. For point to responses, three stimuli were presented in a horizontal array (two non- exemplars and one target exemplar) with the vocal antecedent of "point to". For tact and intraverbal responses, stimuli were presented in random order ensuring that target stimuli were not presented consecutively. Correct responses were those that corresponded to the discriminative stimulus and were emitted within 5 s of the discriminative stimulus. Incorrect responses were those that did not correspond to the discriminative stimulus or no response within 5 s. The assessment of each topography included 20 unconsequated LU opportunities and we calculated the percentage correct as number of correct LUs divided by 20 and multiplied by 100.

Independent Variable

We evaluated two independent variables in this study. First, for each participant, we rotated between two training and derived relations conditions: 1) in the listener protocol, we directly reinforced listener responses and tested for the emergence of related speaker responses. 2) in the speaker protocol, we directly reinforced speaker (tact) responses and tested for the emergence of related listener (point to conditional discriminations) responses.

Second, we examined derived relations performances according to categories of bidirectional naming that participants demonstrated at the start of the experiment. All participants were exposed to object-name relations and were assessed for corresponding speaker (tact, intraverbal) and listener (point to) responses 2-hr later. Participants who scored 80% or higher on speaker and listener responses were categorizes as having BiN. Participants who scored 80% or higher on listener responses, but below 80% on speaker responses were categorized as UniN. Participants who scored below 80% for both speaker and listener responses we categorized as having no incidental naming (NiN).

Procedures

Participants were first categorized by degrees of bidirectional naming (i.e., NiN, UniN or BiN) then selected to complete a training protocol; selection was randomized (see Figure 1). Below describes each component in detail.

BiN assessment. The BiN assessment was composed of two components, exposure to name-object relations and the assessment of corresponding speaker and listener responses. During the exposure, the researcher obtained the participant's attention, provided identity matching trials, named the stimulus during the trials, and provided consequences contingent on the participant's match response (not contingent on responses in accordance with the name, such as an echoic). At the start of each trial, the researcher laid out three stimuli in front of the participant (two non- target exemplars and the target stimuli), presented the participant with the target exemplar and the antecedent, "Match ____ to _____" (e.g., "Match Krumm to Krumm"). Contingent upon a correct matching response, the researcher provided social consequences such as vocal praise and playful physical contact. If the participant matched the target stimulus to a non-exemplar or did not respond within 3 s, the researcher implemented a correction procedure whereby she modeled the correct matching response and represented the antecedent to allow the participant the opportunity to independently respond. Each session was composed of 20 match responses (five stimuli with 4 LUs per stimulus). BiN exposure sessions were continued until a participant responded with 90% matching accuracy during one session. It is important to note that there were no contingencies arranged for responding to the researcher's modeling of object-name relations.

The second component of the BiN assessment was a test for corresponding listener and speaker responses. After the BiN exposure, the researcher assessed corresponding listener and speaker responses 2-hr later. Three responses were measured. The researcher assessed listener responses by presenting the participant with three stimuli (two non-exemplars and one target stimulus) and the vocal direction "Point to _____". For speaker responses, the researcher assessed pure and impure tacts. For pure tacts, the researcher held one stimulus in front of the participant and waited up to 5 s for the participant to provide the corresponding tact (name). For impure tacts, the researcher conducted trials similar to pure tact trials and added the vocal direction, "What is this?" The researcher conducted 20 LUs for each response type (point to, pure tact, impure tact), which was composed of 4 LUs opportunities to respond to each of five stimuli. During this probe for listener and speaker responses, the researcher provided no accuracy feedback, but intermittently praised academically related behaviors such as sitting and attending.

Derived Relations Protocols. During each training phase, participants were taught either listener or speaker relations and then tested in the untaught topography (i.e., derived relational responding). Training phases were conducted as learn unit instruction (Albers & Greer, 1991). Upon emitting a correct response, the researcher delivered vocal praise, playful physical contact, or a token. The researcher engaged in a correction procedure contingent on incorrect responses. During derived relations phases, the researcher provided no feedback.

Pre-assessments. Pre-assessments were conducted for both listener and speaker responses at the onset of the study to ensure we taught responses not already in each participant's repertoire. Letter-name-and sound assessment included the letter names and letter sounds for all 26 letters in the alphabet. During the pre-assessment, one sample stimulus was presented at a time, where the participant was instructed to respond to "What letter is this?" or "What sound does this make?" During the pre-assessment and probe sessions no consequences were delivered for correct and incorrect responses. The pre-assessment consisted of 52 responses for letter names/sounds. The researcher randomized the order of presenting letters for each participant. After completing the pre-assessment, the researcher chose letters to teach based on those the participant responded to incorrectly during the pre-assessment and the researcher eliminated letters for which a participant responded accurately to. Preliminary data indicated that five of the selected participants had previously mastered selected letter names and sounds. Therefore, a pre-assessment on 100 pre-primer Dolch words were conducted in the same manner. During the pre-assessment, one sample was presented at a time, where the participant was instructed to "read". During the pre-assessment and probe sessions no consequences were delivered for correct and incorrect responses. The researcher randomized the order of words for each participant. After completing the pre-assessment, the researcher chose 16 words to teach based on those the participant responded to incorrectly during the pre-assessment and the researcher eliminated words to which a participant responded accurately. It is important to note that the same sight words were selected for all participants, that is, words were chosen based on the incorrect responses for all participants.

Refer to Table 1 for participant sequence, note that Participant BiN- 1, BiN-2, BiN-3, BiN-4, UniN-1, and UniN-2 learned sight words, the remaining participants learned letter names and sounds.

Listener training protocol. The listener training protocol consisted of teaching the participant to identify target stimuli with a point response, followed by tests of the emergence of corresponding speaker responses. For letter names and sounds instruction, the training phase consisted of two experimentally defined responses (i.e., letter names and letter sound). For each session, instruction was presented in a rotated sequence. The participant received 15 LU opportunities to point to the letter name and 15 LU opportunities to point to the letter sound, for a total of 30 LUs. The criterion for each response was 90% accuracy for two consecutive sessions or 100% accuracy in one session. During each session, the researcher presented an array of three stimuli, one target exemplar and two non-target exemplars. After presenting the stimuli, the researcher presented the vocal antecedent (e.g., "point to M"/ "point to /m/") and allowed 5 s for the participant to respond. If the participant pointed to the target exemplar, the researcher provided social consequences (i.e., vocal praise, playful physical contact, tokens). If the participants emitted an incorrect response, the researcher implemented a correction procedure. For the correction procedure, the researcher modeled the correct response (i.e., pointed to the target stimulus), and 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 researcher modeled the response up to three times before proceeding to the next learn unit. The researchers provided no consequences for corrected responses.

Researchers taught sight words in the same manner as letter names and sounds, with minor exceptions. The researcher administered 20 learn units per sessions, composed of 5 LU opportunities to point to each of four sight word. During each session, the researcher presented an array of three stimuli, one target exemplar and two non-target exemplars. After presenting the stimuli, the researcher presented the vocal antecedent (e.g., “point to after”) and allowed 5 s for the participant to respond.

After a participant’s responding met mastery criterion during the listener training protocol portion, the researcher assessed derived speaker responses. The researcher presented each stimulus on the laptop via Microsoft PowerPoint©, said, “What letter is this? / “what sound does this make?”, and waited up to 5 s for the participant to respond. For letter names and sounds derived relations, there were 12 LUs in a session, which was composed of three stimuli, two responses (e.g., letter name, letter sound), and two opportunities of each learn unit type. For sight word derived relations, there were 6 unconsequated LUs in a session, which was composed of three stimuli and 2 opportunities of each learn unit type. Criterion for the demonstration of the derived relational responding was 80% accuracy in one session[1].

Speaker training protocol. The speaker training protocol consisted of teaching the participant to textually respond to target stimuli (e.g., selected sight, followed by tests of the emergence of corresponding listener responses. For letter names and sounds instruction, the training phase consisted of two experimentally defined responses (i.e., letter name and letter sound). For each session, instruction was presented in a rotated sequence. The participant received 15 LU opportunities to answer the intraverbal tact response of letter name (i.e., “What letter is this?”) and 15 LU opportunities to intraverbal tact response of letter sound (i.e., “What sound does this make?”), for a total of 30 LU. The criterion for each response was 90% accuracy

[1] It is common practice to select 90% as criterion to demonstrate mastery of derived relations, but in this case 80% was selected due to the number of opportunities presented (i.e., totaling 6). The student could emit one error (83%) and is still said to have derived relational responding.

for two consecutive sessions or 100% accuracy across one session. During each session, the researcher presented the target exemplar on a laptop via Microsoft Office PowerPoint © with the vocal antecedent and followed 5 s for the participant respond. If the participant emitted the target response the researcher provided social consequences (i.e., vocal praise, playful physical contact, tokens). If the participants emitted an incorrect response, the researcher implemented a correction procedure. For the correction procedure, the researcher modeled the correct response (e.g., "/m/" or "m"), and 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 researcher modeled the response up to three times before proceeding to the next learn unit. The researchers provided no consequences for corrected responses. Data were collected and recorded in the same manner as stated above. The same procedure was implemented for the participants that were taught sight words.

Researchers taught sight words in the same manner as letter names and sounds, with minor exceptions. The researcher administered 20 learn units per sessions, composed of 5 LU opportunities to textually respond/tact each of the four sight words. During each session, the researcher presented one target exemplar on the laptop screen via Microsoft Office PowerPoint ©. After presenting the stimuli, the researcher presented the vocal antecedent "read" and allowed 5 s for the participant to respond.

After a participant's responding met mastery criterion during the speaker training protocol portion, the researcher assessed derived listener responses. The researcher presented each stimulus on the laptop via Microsoft Office PowerPoint© and said, "point to the letter m / "point to the letter that makes the /mm/ sound?" or "point to here", and waited up to 5 s for the participant to respond. For letter names and sounds derived relations, there were 12 learn units in a session, which was composed of three stimuli, two responses (e.g., letter name, letter sound), and two opportunities of each learn unit type. For sight word derived relations, there were 6 unconsequated LUs in a session, which was composed of three stimuli and 2 opportunities of each learn unit type. Criterion for the demonstration of the derived relational responding was 80% accuracy in one session[1].

Procedural Modifications

Decision to stop protocol. The researcher ended training portions of protocols contingent on a participant mastering the respective protocol. Additionally, we implemented a decision protocol (Keohane & Greer, 2005) to make decisions about whether to stop instruction if learning was not occurring. We implemented the decision protocol as an ethical guard against keeping participants in a training phase when additional instructional supports were needed beyond the purview of this experiment. We analyzed data paths, or the line connecting two consecutive data points. "Stop" decisions in the decision protocol included 0% accuracy in 1 session, 3 consecutive descending data paths, or 5 variable and overall descending data paths. We terminated a training phases contingent on the data meeting two stop decisions. This rule only affected NiN participants.

Experimental Design

The researchers implemented a counterbalanced ABAB within-subjects design (Baer, Wolf & Risley, 1968) to test the effects of direct instruction on one topography on the emergence of the derived responses. The order of trainings (listener or speaker protocols) were counterbalanced across participants. For example, Participant BiN-1 started with the listener training phase while Participant BiN-2 started with the speaker training phase. We also counterbalanced the assignment of specific stimuli to protocols across participants. For example, the set of stimuli assigned to Participant UniN-1's listener protocol was assigned to Participant UniN-2's speaker protocol.

Each participant progressed through the respective conditions (listener training protocol or speaker training protocol) at their own pace until mastery was met in each condition and the participant rotated through each condition two times, for a total of four conditions. The researcher conducted tests for derived relations immediately following mastery of the respective relations.

Interobserver Agreement and Procedural Fidelity

A second, independent observer collected data for the purposes of calculating interobserver agreement (IOA) using the Teacher Performance Accuracy Rate Observation form (TPRA, Ingham & Greer, 1992). The researchers calculated trial-by-trial IOA by counting the number of learn units on which researcher and independent observer agreed, divided that number by the total number of opportunities presented, and multiplied the resulting number by 100. IOA was collected for 56% of the BiN probe (i.e., untaught response topographies after BiN exposure) sessions and 16% of the training sessions (i.e., listener and speaker training phases) with 100% agreement. IOA was calculated for 100% of the derived relations sessions and agreement was 98% (range = 95% -100%).

The independent observer also collected procedural fidelity data using the TPRA form. Per observation, the independent observer rated the accuracy of researcher-delivered antecedents and consequences. Fidelity was calculated by dividing the number of correct components divided by the total number of components multiplied by 100. Fidelity data were collected for 100% of BiN probe sessions and 10% of the training sessions. Fidelity was 98% with a range of 95%-100%.

Results and Discussion

Listener and Speaker Protocol Performances

Each participant completed speaker and listener trainings and tests for untaught, derived relations. Below we categorize outcomes by level of BiN at the start of the study. Figures 2, 3, and 4 display the training and derived relations data for participants with BiN, UniN, and NiN, respectively. In each graph, all listener responses are grey, such that grey data points represent listener trainings and grey bars represent derived listener responses. All speaker responses are black, such that black data points represent speaker training and black bars represent derived speaker responses.

Participants with BiN. Figure 2 displays the training and derived relations data for 3 BiN participants. All BiN participants steadily achieved mastery criterion during the respective trainings and met criterion levels during all derived relations probes. Participant BiN-1 learned speaker responses in an average of 60 LUs (3 sessions) and derived listener responses with 100% accuracy. BiN-1 learned listener responses in an average of 20 LUs (1 session) and derived speaker responses with 100% accuracy. Participant BiN-2 learned speaker responses in an average of 50 LUs (2.5 sessions) and derived listener responses with 100% accuracy. BiN-2 learned listener responses in an average of 30 LUs (1.5 sessions) and derived speaker responses with 100% accuracy. Participant BiN-3 learned speaker responses in an average 80 LUs (4 sessions) for both sets and derived listener responses with 100% accuracy. Participant BiN-3 learned listener responses in an average of 100 LUs (5 sessions) and derived speaker responses with 97% (94% to 100%) accuracy. Overall, BiN participants readily acquired speaker and listener responses under direct reinforcement contingencies and derived corresponding listener and speaker responses.

Participants with UniN. Figure 3 displays the training and derived relations data for 8 UniN participants. All UniN participants steadily achieved mastery criterion during the respective trainings and met criterion levels during derived listener relation probes. Participant UniN-1 learned speaker responses in an average of 120 LUs (6 sessions) for both sets and derived listener responses with 87.5% accuracy. UniN-1 learned listener responses in an average of 140 LUs (7 session) and derived speaker responses with 31.25% accuracy. UniN-2 learned speaker responses in an average of 120 LUs (6 sessions) for both sets and derived listener responses with 87.5% accuracy. UniN-2 learned listener responses in an average 140 LUs (7 session) and derived speaker responses with 31.25% accuracy. UniN-3 learned speaker responses in an average of 100 LUs (3.5 sessions) and derived listener responses with 100% accuracy. UniN-3 learned listener responses in an average of 30 LUs (2 session) and derived speaker responses with 29.17% accuracy. UniN-4 learned speaker responses in an average of 100 LUs (3.5 sessions) and derived listener responses with 95.83% accuracy. UniN-4 learned listener responses in an average 30 LUs (2 session) and derived speaker responses with 100% accuracy. UniN-5 learned speaker responses in an average of 165 LUs (5.5 sessions) and derived listener responses with 95.83% accuracy. UniN-5 learned listener responses in an average of 135 LUs (4.5 session) and derived speaker responses with 25% accuracy. UniN-6 learned speaker responses in an average of 255 LUs (8.5 sessions) and derived listener responses with 95.83% accuracy. UniN-6 learned listener responses in an average of 75 LUs (2.5 session) and derived speaker responses with 50% accuracy. UniN-7 learned speaker responses in an average of 130 LUs (4.5 sessions) and derived listener responses with 83.33% accuracy. UniN-7 learned listener responses in an average 180 LUs (6 session) and derived speaker responses with 41.67% accuracy. UniN-8 learned speaker responses in an average of 180 LUs (6 sessions) and derived listener responses with 83.33% accuracy. UniN-8 learned listener responses in an average of 180 LUs (6 session) and derived speaker responses with 41.67% accuracy. It is important to note that participant UniN-8 only completed one speaker and listener training. Intervention was discontinued due to missing instructional history. In the current case, missing instructional history was defined student not attending to stimuli for more than 50% of session. Overall, UniN participants readily acquired speaker responses under direct reinforcement contingencies and derived corresponding listener responses, but were unable to derive speaker responses under listener trainings.

Participants with NiN. Figure 4 displays the training and derived relations data for 3 NiN participants. NiN participants only completed an AB or BA rotation due to the lack of prerequisite skills needed in order to complete the academic task, such as attending to stimuli. All NiN participant's performances met the decision protocol rules to stop a training phase and no NiN participant met criterion levels during derived relations probes. Participant NiN-1 was exposed to 330 LUs (11 sessions) of speaker responses before two consecutive decisions were made to stop (i.e., 3 overall descending data paths and 5 variable paths). Participant NiN-1 was then tested for derived listener responses and responded with 91.7% accuracy. Participant NiN-1 then moved to listener training protocol where they learned listener responses in an average of 150 LUs (5 session) and derived speaker responses with 50% accuracy. Participant NiN-2 was exposed to 60 LUs (3 sessions) of speaker responses before 2 consecutive decisions were made to stop (i.e., 2 consecutive 0 correct LU responses). Participants NiN- 2 then moved to derived listener responses and responded with 66.67% accuracy. NiN-2 was exposed to an average of 270 LUs (9 sessions) of speaker responses before 2 consecutive decisions were made to stop (i.e., 2 consecutive 5 variable data paths). Participant NiN-2 then moved to derived listener responses and responded with 33.33% accuracy. Participant NiN-3 was exposed to a 270 LUs (9 sessions) of speaker responses before two consecutive decisions were made to stop (i.e., 0 correct responses and 5 overall descending data paths). Participant NiN-3 then moved to derived listener responses and responded with 41.67% accuracy. Participant NiN-3 was exposed to an average of 180 LUs (6 sessions) of listener responses before 2 consecutive decisions were made to stop (i.e., 5 overall variable data paths). Participant NiN-3 then moved derived speaker responses and responded with 16.67% accuracy. Overall, NiN participants did not acquire derived listener or speaker responses under direct reinforcement contingencies for both training conditions.

Summary. Overall, participants with BiN derived both listener and speaker responses, independent of the training protocol. Additionally, they also had a faster rate of acquisition during both trainings; approximately half of their UniN counterparts. UniN participants derived listener responses after completing speaker trainings, but not vice versa. These results are consistent with VBDT, which states that listener behavior precedes speaker behavior (Greer & Speckman, 2009). Furthermore, all NiN participants had variable responding across trainings, and demonstrated a lack of derived relational responding for both listener and speaker responses.

Outcomes According to Degrees of Bidirectional Naming

In the following analysis, we compare outcomes based on each participant's degree of bi-directional naming at the start of the study, categorized as BiN, UniN, or NiN. Descriptive statistics were calculated for three measures, (a) the mean number of learn units to criterion across all academic programs, (b) learn units to criterion across the derived listener training protocol, and (c) learn units to criterion across the derived speaker training protocol, each are depicted in Table 2.

Learn Units to Criterion. We compared the number of learn units required to master listener and speaker responses. We omitted data from NiN participants because these participants responding often met the stop decision protocol rule. Thus, below we report data on BiN and UniN participants (refer to Table 3). Overall, UniN participants had a higher average of overall learn units to criterion (*M*=232.88, *SD* = 54.73) than BiN participants (*M*=134. *SD*=10.15) – meaning UniN participants required more learning opportunities to respond at criterion. An independent-samples t-test was conducted to compare the differences among the degree bi-directional in terms of learn units to criterion (i.e., LUC). There was a statistically significant difference between UniN participants and BiN participants in the overall number of learn units to criterion, t (9) =3.01, p=.015. These findings correspond to previous research that show students with BiN learn at a faster rate and require fewer learn units to meet criterion (Greer & Longano, 2010; Hranchuk, Greer, & Longano, 2019; Greer, Corwin, & Buttigieg, 2011). As our results show, BiN participants required fewer learn units to meet criterion than those with UniN. Additionally, these results also revealed that learn units to criterion across listener and speaker trainings were not statistically significant, t (9) =0.687, p=0.59 and t (9) =.857, p=0.414, respectively.

The current data failed the tests of normality; hence we analyzed the data using nonparametric analysis. Specifically, a nonparametric analysis of variance (ANOVA) procedure was used; Kruskal-Wallis, as well as a Spearman correlation.

The nonparametric Kruskal-Wallis test revealed a statistically significant difference among the degree of bi-directional naming in terms on learn units to criterion (i.e., LUC), F (2,11) = 9.138, p= .005, and learn units to criterion across the speaker protocol, F (2,11) = 5.595, p= .021. It also revealed that there was not statistically significant difference between the degrees of bi-directional naming and learn units to criterion across the listener protocol, $F(2,11) = 3.388$, $p = .071$, suggesting that participant's efficiency in learning listener responses is not affected by the degree of bi-directional naming.

A post-hoc analyses revealed that students who have incidental bidirectional Naming (BiN) reported lower learn units to criterion overall ($M = 134.000$, $SD = 10.15$) $p = 0.015$ than those who had Uni-directional Naming (UniN) ($M = 232.875$, $SD = 10.15$) $p = 0.077$. A series of nonparametric pairwise follow-up tests at the Bonferroni adjusted level of $p < .05$ indicated a statistically significant difference between students who demonstrated BiN and those who had NiN or UniN. There was a statistically significant difference between the overall learn units to criterion by the degree of BiN ($H(2) = 9.003$, $p = .011$), with a mean rank of 12.17 for those with NiN, 7.81 for those with UniN, and 2.00 for those with BiN.

Derived Relations. Figure 5 displays the percentage of derived speaker and listener responses grouped by degrees of bidirectional Naming. Overall, participants who demonstrated BiN were able to derived the untaught topography, regardless of topography, whereas participants who demonstrated UniN they were able to derive 98% of the listener responses (following speaker training) and 51% of the speaker listener (following listener training). Participants who demonstrated NiN, were unable to derive the untaught relation at criteria levels, which was not surprising given that these participants did not meet mastery criterion during trainings.

A Spearman correlation was used to measure the strength and direction of the varying degrees of Bidirectional Naming (i.e., NiN, UniN, and BiN). Results of the Spearman correlation was conducted across the level of BiN, derived listener training protocol session indicated that there was a significant negative correlation between the degrees of BiN and the overall all learn units to criterion $(r_s\ (14) = -0.827), p < 0.001$. Further results indicate, that there was a positive correlation between the derived listener and speaker training protocols learn units and the overall learn units to criterion. Results indicated, $(r_s\ (14) = .567), p = 0.035$, and $(r_s\ (14) = .745), p = 0.002$, across derived speaker training protocols and listener training protocols, respectively.

Summary

The findings from Experiment 1 demonstrate a strong association between a participant's degree of BiN and derived relations. Specifically, participants who demonstrated NiN struggled to acquire both listener and speaker responses and subsequently failed to derive corresponding speaker and listener relations. Participants who demonstrated UniN acquired both listener and speaker responses under direct reinforcement conditions and derived listener, but not speaker responses. Last, participants who demonstrated BiN acquired both listener and speaker responses under direct reinforcement conditions and derived both speaker and listener responses. The current findings suggest a relation between bidirectional naming and derived relations and pinpoint how different subcategories of bidirectional naming are associated with different types of derived relations.

These data support research which has suggested that the student's verbal repertoires do interact with the establishment of derived relational responses (Miguel, 2014; Sprinkle & Miguel, 2012; Miguel, 2008). These findings extend on previous research including Greer, Stolfi, Chavez- Brown, and Riveria (2005), who found that individuals with the listener half of naming (UniN) can reliably emit listener responses after learning object-word relations, but not speaker responses, which is consistent with the current study's findings, suggesting that students who demonstrate UniN can emit listener responses, independent of their training condition. The current study identifies the type of training (speaker or listener) required to yield the maximum outcome.

Participants who demonstrated BiN demonstrated derived relations independent of type training protocol. Previous research has demonstrated that students with BiN learn at a faster rate and require fewer learn units and can learn from antecedent stimulus presentations alone; while students without BiN require direct reinforcement to learn new responses (Greer et al., 2011). This study builds on previous research by examining how bidirectional naming differentiates derived speaker and listener responses. This study also examines participants who have no incidental naming and the relation that it may have on relational responses, results indicated that these participants were unable to derive at criterion levels and suggest that the cusp of UniN should be established if the necessary prerequisite skills are present.

EXPERIMENT 2

Eikeseth and Smith (1992) conducted a study and the findings suggested that students who initially failed emergent relations tests after listener trainings, produced emergent performance after speaker trainings. These results denote that a student may only produce emergent performance after completing speaker trainings, but not after listener trainings. Once naming is established discrimination training such as, match-to-sample procedure (i.e., listener training) can produce emergent performance as a speaker, and vice versa. Research surrounding both listener and speaker trainings report mixed findings, suggesting that these trainings may not be intended for all learners across the board but rather it should be tailored to students based on skills that they may have in their repertoire. The discrepancies raise questions regarding “for whom?” – for whom do the outcomes apply. The results of Experiment 1 demonstrated correlations between an individual’s degree of bidirectional naming and both the acquisition of listener and speaker responses and derived speaker and listener responses. However, we found this association based on the degree of bidirectional naming that a participant entered the experiment with. Thus, it remains to be seen how changing a participant's bidirectional naming repertoire leads to corresponding changes in derived relations. Thus, in Experiment 2, we examined this phenomenon within-subjects and established BiN for participants who entered Experiment 1 with UniN capabilities. Participants categorized as having UniN in Experiment 1 served as participants in Experiment 2. First, we established BiN for the UniN participants from Experiment 1 using multiple-exemplar instruction (MEI; Greer, Stolfi, Pistoljevic, 2007; Hawkins, Kingsdorf, Charnock, Szabo, & Gautreaux, 2009; LaFrance & Tarbox, 2019). MEI involved teaching new responses and rotating between multiple exemplars and multiple topographies (match, point to, tact, intraverbal) during sessions until participants mastered all responses. Once a participant mastered MEI and passed the BiN assessment, we replicated the derived relations assessments from Experiment 1 in order to observe whether each participant's responses to derived relations changed as a function of improving BiN repertoires. Our analysis focused on the learn-units-to-criterion before and after the induction of bidirectional naming and the percentage of derived speaker and listener responses.

Method

Participants

Six of the eight UniN participants from Experiment 1 met criterion to continue in Experiment 2. Two of the UniN participants from Experiment 1 (Participant UniN-7 and Participant UniN-8 were not included in Experiment 2 because they did not demonstrate an adequate self-management repertoire to continue onto the MEI phase. In the case of MEI, the students are required to sit and attend to the stimuli for longer than 5 min; these students were easily distracted and required dense schedules of reinforcement. Thus, these participants were excluded from Experiment 2, because they lacked the prerequisite skills. Participant UniN-1,2,3,4, 5, and 6 from Experiment 1 participated in Experiment 2.

Settings and Materials

Experiment 2 was conducted in the same setting as Experiment 1. Table 5 lists the stimuli used during MEI. The stimuli were printed on index cards measuring 3 cm by 4 cm. We used the similar materials as described in Experiment 1 for the BiN assessment and derived relations protocols.

Measurement

We measured BiN and derived relations the same as in Experiment 1. During MEI, we measured the accuracy of four response topographies: 1) match, 2) point to, 3) tact, and 4) intraverbal. MEI data were collected using learn unit instruction (Albers & Greer, 1991), where correct responses were reinforced and recorded as a plus (+), and incorrect responses were recorded as a minus (-), and a correction procedure was utilized. For match responses, three stimuli were presented in a horizontal array (two non- exemplars and one target exemplar), the participants was then handed the target stimulus and given the vocal antecedent of "Match___ to ______". For point to responses, three stimuli were presented in a horizontal array (two non-exemplars and one target exemplar) with the vocal antecedent of "point to". For tact and intraverbal responses, stimuli were presented in random order ensuring that target stimuli were not presented consecutively. Correct responses were those that corresponded to the discriminative stimulus and were emitted within 5 s of the discriminative stimulus. Incorrect responses were those that did not correspond to the discriminative stimulus or no response within 5 s. All learn units were rotated across topographies and operants (see Table 6).

Independent Variable

The independent variable was the establishment of bidirectional naming. We implemented MEI to establish bidirectional naming and examined corresponding changes in derived relations as compared to those reported in Experiment 1.

Procedure

BiN assessments. The same BiN assessments described in Experiment 1 were implemented in Experiment 2. BiN assessments were conducted each time a participant met criterion during MEI. If a participant's behavior met criterion for BiN (80% accuracy or higher for listener and speaker relations), the researcher moved the participant on to the derived relations protocols. If a participant's behavior did not meet criterion another round of MEI was conducted.

MEI. This procedure involved the rotation of listener and speaker topographies during instructional session and the incorporation of multiple exemplars of stimuli. For example, if teaching animals (e.g., dog, cat, mouse), the researcher first produces 4 pictures of each animal that vary in form. Next, during instruction the researcher rotates between listener (match, point to responses) and speaker (tact, intraverbal) responses across the animal stimuli. A single complete MEI session consisted of 80 learn units, composed of five stimuli (and corresponding multiple exemplars), four topographies, and 4 opportunities to respond to each topography. The criterion for terminating a phase of MEI was 90% accuracy across two consecutive sessions or 100% accuracy in one session. The researcher selected novel cartoon characters to assist in motivating the student to attend to the stimuli.

After criterion was met for each set of MEI, researchers conducted a BiN assessment. If a student demonstrated BiN (i.e., achieving 80% accuracy across listener and speaker responses) another BiN assessment was conducted using a novel set to confirm the establishment of BiN. If the student did not demonstrate BiN, another phase of MEI was implemented with new stimuli. It is important to note that this sequence continued until the student achieved criterion or completed 3 sets of novel MEI sets. After completing 3 sets of MEI, we implemented a stimulus-stimulus pairing procedure (Greer & Longano, 2010).

Stimulus-Stimulus Pairing. Previous research has shown that after the presence of UniN for students with certain existing cusps or stimulus control accrue reinforcement stimulus control for the speaker component as a result of pairings that are the same as repetition of probes, as were done in the pre and post assessments (Kleinhart, 2017). The repeated probe procedure consisted of repeated BiN assessment with the same set until criterion levels of 80% accuracy across topographies. It is important to note that the BiN experience was only conducted once and the subsequent sessions consisted of the BiN assessment (i.e., point to, tact, and intraverbal responses – untaught topographies (refer to Experiment 1). The BiN assessment probe repetitions were unconsequated and participants repeated the BiN assessment until they demonstrated criterion of 80% accuracy. All phases consisted of tests for listener or speaker responses without repeating the BiN experience. The predetermined criterion for mastery of the intervention was 80% accuracy across all response topographies (i.e., point, tact, and intraverbal) in a single BiN assessment.

Derived relations protocols. For Experiment 2 speaker and listener protocol conditions were presented in the same manner as described in Experiment I, including the pre-assessment of targets taught during these phases. The only difference between Experiment 1 and Experiment 2 was the type of target operants taught. In this experiment, all participant learned sight words.

Decisions to stop a protocol. We used the same decision protocol (Keohane & Greer, 2005) to as described in Experiment 1; however, no performances met the decision protocol rules and thus no training was stopped.

Experimental Design

The design utilized in this study was a pre- and post-assessment design. Participants underwent listener and speaker protocols in Experiment 1, then we induced BiN for each participant, and last, once the participant demonstrated the BiN capability, we replicated the rotating of listener and speaker protocols.

Interobserver Agreement and Treatment Fidelity

Interobserver agreement (IOA) was collected using the TPRA (Ingham & Greer, 1992). IOA was calculated by dividing the number of items in agreement by the total number of stimuli presented and multiplying by 100. IOA was collected for 93% of the BiN assessments and 37.5% of the MEI intervention sessions, with a mean agreement of 98% (range 95%-100%). The researchers calculated trial-by-trial interobserver agreement by counting the number of learn units on which researcher and independent observer agreed and dividing it by the total number of learn units. IOA was collected for 63% of the derived response probes with a mean agreement of 100% accuracy.

Treatment fidelity was measured in the form of Teacher Performance Rate Accuracy (TRPA) forms (Ingram, Greer, 1992). During these observations, an observer simultaneously and independently collected data on student responses and teacher's adherence to the learn unit protocol (i.e., instructional fidelity in presenting learn units). Treatment fidelity was calculated for 32% of all establishment of BiN intervention sessions, 78% of the BiN assessment probes, 58% for tests of derived relations (29% for derived listener responses and 29% for derived speaker responses) with mean fidelity of 95% and a range of 93% to 100%. Across trainings sessions, treatment fidelity was calculated across 14% of listener trainings sessions and 4% of speaker training sessions.

Results and Discussion

Establishment of BiN

Table 4 displays the pre- and post-intervention probe data for all six participants. During their first pre-intervention probes, all six participants emitted 95% or higher correct responding on the point topography, thus meeting the criteria for UniN. However, all six participants emitted few correct responses across speaker topographies (tact and intraverbal) indicating that they did not have BiN in their repertoires.

Participants mastered MEI in an average of 382 LUs (range = 240 to 560). Participants required between 1 and 4 sets of MEI before demonstrating the BiN repertoire. Following the initial probe, researchers conducted a second pre-MEI probe with all participants. The number of correct responses to the point topography remained similar for five out of six participants, suggesting that they all had UniN prior to the onset of the MEI intervention. The number of speaker responses varied across participants during the initial probe. Table 4 displays the MEI performance data. Overall, all participants were able to acquire the capability of BiN, through MEI or repeated probe measures.

Listener and Speaker Protocol Performances

Each participant completed speaker and listener trainings and tests for untaught, derived relations. Figure 6 displays the training and derived relations data for 6 UniN participants. Recall that this occurred following the establishment of BiN. All UniN participants steadily achieved mastery criterion during the respective trainings. All UniN participants met criterion levels during derived listener probe, whereas four of six participants met criterion levels during derived speaker relation probes. Participant UniN-1 learned speaker responses in an average of 90 LUs (3 sessions) and derived listener responses with 94% accuracy. UniN-1 learned listener responses in an average of 60 LUs (2 session) and derived speaker responses with 56.5% accuracy. UniN-2 learned speaker responses in an average of 165 LUs (5.5 sessions) and derived listener responses with 100% accuracy. UniN-2 learned listener responses in an average 60 LUs (2 session) and derived speaker responses with 87% accuracy. UniN-3 learned speaker responses in an average of 195 LUs (6.5 sessions) and derived listener responses with 100% accuracy. UniN-3 learned listener responses in an average of 75 LUs (2.5 session) and derived speaker responses with 91.5% accuracy. UniN-4 learned speaker responses in an average of 100 LUs (3.5 sessions) and derived listener responses with 95% accuracy. UniN-4 learned listener responses in an average 120 LUs (4 session) and derived speaker responses with 100% accuracy. UniN-5 learned speaker responses in an average of 135 LUs (4.5 sessions) and derived listener responses with 100% accuracy. UniN-5 learned listener responses in an average of 90 LUs (3 session) and derived speaker responses with 91.5% accuracy. UniN-6 learned speaker responses in an average of 90 LUs (3 sessions) and derived listener responses with 100% accuracy. UniN-6 learned listener responses in an average of 60 LUs (2 sessions) and derived speaker responses with 66.5% accuracy. Overall, four of the six UniN participants readily acquired both listener and speaker responses under direct reinforcement contingencies and derived corresponding responses.

Outcomes Comparing Pre- and Post-BiN

Learn units to criterion. Figure 7 displays the learn units to criterion pre-and-post the establishment of BiN. We compared the number of learn units required to master listener and speaker responses before and after the acquisition of BiN. Participants reported a higher learn units to criterion pre-BiN (*M*= 117.93, *SD*= 39.95) than post-BiN (*M*= 80.21, *SD*= 22.86). A dependent-samples t-test was conducted to compare the differences among the pre-BiN and post BiN learn units. There was not statistically significant difference between pre-BiN and post BiN participants in the overall number of learn units to criterion, t (5) =1.969, p=.12. Even though the results were not statistically significant these findings correspond to previous research that show students with BiN learn at a faster rate and require fewer learn units to meet criterion (Greer & Longano, 2010; Hranchuk, Greer, & Longano, 2019; Greer, Corwin, & Buttigieg, 2011). Additionally, these results also revealed that learn units to criterion across listener and speaker trainings decreased at a substantial rate after the acquisition of BiN, approximately a 50 and 25 mean difference, respectively.

Acquisition of Listener and Speaker Responses

Figure 6 displays the derived responses of the untaught response topographies for the 6 UniN participants (i.e., Participant UniN-1, Participant UniN-2, Participant UniN-3, Participant UniN-4, Participant UniN-5, and Participant UniN-6). All participants derived 100% of listener responses and 56.5%, 87.5%, 100%,100%, 46.5%, and 66.5% of speaker responses, respectively. All participants showed an increase in derived relational responding. In comparison to the rate of acquisition each student decreased their learn units to criterion. Results were similar to Experiment 1 where once the participants established the capability of BiN they performed similarly to the BiN participants. Demonstrating that once a student acquires the capability of BiN they learn at a faster rate and access information in a new way (i.e., incidental learning).

Derived Relational Responding Post Induction of BiN

Figure 8 shows the percentage of derived relation across untaught topographies for participants, before (left side) and after (right side) the acquisition of BiN. Results were similar to Experiment 1, where once the student acquired the capability of BiN, they were able to derive the untaught relation, independent of training protocol condition, similar to the BiN participants in Experiment 1. Participant UniN- 4, did demonstrate high levels of relational responding before and after the acquisition, suggesting that another subtype of BiN was present at the onset of the study (Hawkins et al., 2018). Before the establishment of BiN, Participant UniN-1, emitted an average of 31.25% correct speaker responses, after the acquisition of BiN they emitted an average of 56.50% of correct speaker responses, showing a 35.25% increase. Similarly, Participant UniN-2, 3, and 5, showed an increase in correct speaker responses, 31.25%, 70.83.5%, and 16.5%, respectively. Overall, all participants increased in correct responding but not consistently to mastery levels. Each participant increased in the number of correct responses emitted during both listener and speaker trainings, and showed an average of 29.22% increase in derived relational speaker responding. Figure 5, shows the percentage of derived relational responding for each participant, the dotted line represents the predetermined criteria for achieving relational responding.

General Discussion

Across two experiments, we studied the intersection of verbal behavior measures of bidirectional naming and derived responses. The outcomes of the experiments suggest commonalities among bidirectional naming and derived relations. In Experiment 1, participants with the BiN capability, who learn listener and speaker responses from antecedents alone, derived both listener and speaker responses with high levels of accuracy. Participants with the

UniN cusps that is a capability, who learn listener but not speaker responses from antecedents, derived listener but not speaker responses. Participants who could not learn listener or speaker responses from antecedents (no incidental naming, or NiN) struggled to acquire listener and speaker responses and did not derive corresponding responses. In Experiment 2, we further supported a correspondence between bidirectional naming and derived relations by establishing bidirectional naming with participants and observing corresponding changes in those participants accuracy of deriving relation. Specifically, UniN participants from Experiment 1 developed the stimulus control for BiN and then were able to derive speaker responses as they had been able to derive listener responses during Experiment 1. These participants' performances at the end of Experiment 2 mimicked those of BiN participants in Experiment 1.

The outcomes of this study replicate and clarify previous research. Similar to Eikeseth and Smith (1992), we observed participants derive a full range of responses when the child demonstrated the BiN capability (BiN participants, Experiment 1) or when we induced this capability (Experiment 2). The current study clarifies the outcomes of previous research (e.g., Petursdottir et al., 2008; Sprinkle & Miguel, 2012) suggesting that degrees of BiN predict the capacity to derive speaker and listener relations. These findings are similar to the current study, because participants with the BiN capability can learn tacts from antecedents (i.e., they learn the tact from pairings of name-object during listener training and then this shows up in tests of derived speaker responses). Whereas, participants with UniN capability cannot learn tacts from antecedents, which is why they fail the tests of derived speaker responses.

Thus, it is not the case that speaker or listener trainings produce (e.g., Sprinkle & Miguel, 2012) or do not produce (Petursdottir et al., 2008) emergent learning, the effects of these trainings are mediated by the BiN capability (Miguel, 2018). While more data and research are needed to clarify the aforementioned concerns, the data thus far demonstrate a correlation between the degrees of bidirectional naming (specifically UniN and BiN) and derived relations. These relations demonstrate that students with the UniN cusp are able to derive listener responses, after directing learning through the speaker training protocol, but not derive speaker responses after directly learning through the listener training protocol.

Other studies report mixed findings about the most efficient trainings, suggesting that listener and speaker trainings are equivalent (Delfs, Conine, Frampton, Shillingsburg, & Robinson, 2014; Frampton et al, 2017). These studies do not specify the skills of the students at the onset of the study; providing little information about the student's verbal behavior repertoire. The current research distinguished between the degree of bidirectional naming, categorizing a student's verbal behavior repertoire, suggesting that the participants in the previous studies had the capability of BiN. Thus, accounting for the emergence of the untaught relations independent of their training type.

This study has practical implications for instructional design. These data support research which has suggested that the student's verbal repertoires do interact with the establishment of derived relations (Miguel, 2014; Morgan, 2018; Miguel, 2008). Experiment 2 expands these results, demonstrating that when a student with a UniN repertoire acquires the BiN capability, they are able to derive speaker relations following direct reinforcement of listener responses. Thus, the capacity of derived relations expands as verbal capabilities expand. These findings suggest that special education educators cannot apply the "one size fits all" methodology to instruction, rather they should differentiate instruction based a student's verbal behavior repertoire. According to Greer (2018) the ultimate goal in formal education is the acquisition of language incidentally. Though BiN, is a phenomenon that neurotypical children acquire naturally, those with developmental delays might be missing this capability and therefore it needs to be induced. Once students acquire this capability they can learn language incidentally through indirect contact of tacts. As Greer and Ross (2008) point out, the capability of BiN is fundamental for students' success across educational setting. After acquiring both repertoires of observational learning and BiN, students will have mastered the critical tools for incidental learning that allow them to learn independently from experiences (Greer & Speckman, 2009).

This study contained limitations that temper the outcomes and raise issues to be addressed in future research. First, the sample size was small due to the limited student population at the selected site. Future studies should increase sample size across the three degrees of bidirectional naming. More data from NiN and BiN participants are needed to tease out the relation between derived relational responding and the degree of bidirectional naming. Second, researchers should obtain more IOA and fidelity data. Third, the instruction materials were not uniform across participants, which temper the conclusions one can draw from this study. For example, five participants learned using sight words and the other 10 learned letter name and sounds, which also affected the number of LUs per session. Additionally, we demonstrated changes in derived relations for six participants who participated in Experiment 2; however, changes in derived responses occurred with new stimuli (sight words instead of letter names and sounds), constituting a possible confound.

As a result, future research may further investigate the association between the degree of BiN and derived relational responding in more participants across sub-samples. Future research may also study the relation between other capabilities, such as observational learning and gross motor imitation and derived relations. While more data and research are needed to clarify the aforementioned concerns, these data clearly demonstrate that the degree of BiN is correlated with derived relational responding in preschoolers with a disability.

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Table 1

Sequence in acquisition probes and intervention

	STO 1	STO 2	STO 3	STO 4
BiN- 1	Enough, once, said, together *Speaker Training*	Who, people, live, under *Listener Training*	Should, gone, among, through *Speaker Training*	Who, people, live, under *Listener Training*
BiN- 2	Enough, once, said, together *Listener Training*	Who, people, live, under *Speaker Training*	Should, gone, among, through *Listener Training*	Who, people, live, under *Speaker Training*
BiN- 3	Enough, once, said, together *Speaker Training*	Who, people, live, under *Listener Training*	Should, gone, among, through *Speaker Training*	Who, people, live, under *Listener Training*
UniN- 1	Enough, once, said, together *Speaker Training*	Who, people, live, under *Listener Training*	Should, gone, among, through *Speaker Training*	Who, people, live, under *Listener Training*
UniN- 2	Enough, once, said, together *Listener Training*	Who, people, live, under *Speaker Training*	Should, gone, among, through *Listener Training*	Who, people, live, under *Speaker Training*
UniN- 3	M, A, S *Speaker Training*	T, R, I *Listener Training*	C,O,P *Speaker Training*	B,F, G *Listener Training*
UniN- 4	M, A, S *Listener Training*	T, R, I *Speaker Training*	C,O,P *Listener Training*	B,F, G *Speaker Training*
UniN- 5	M, A, T *Speaker Training*	B,L, C *Listener Training*	P,O, R *Speaker Training*	F, G, H *Listener Training*
UniN- 6	M, A, S *Listener Training*	T, R, I *Speaker Training*	C,O,P *Listener Training*	B,F, G *Speaker Training*
UniN- 7	M, A, S *Speaker Training*	T, R, I *Listener Training*	C,O,P *Speaker Training*	B,F, G *Listener Training*
UniN- 8	M, A, S *Listener Training*	T, R, I *Speaker Training*	__________	_____________
NiN- 1	M, A, S *Speaker Training*	T, R, I *Listener Training*	__________	__________
NiN- 2	M, A, S *Speaker Training*	T, R, I *Listener Training*	__________	__________
NiN- 3	M, A, S *Listener Training*	T, R, I *Speaker Training*	__________	__________

Table 2

Demographics and group characteristics per degree of BiN,

	No Incidental Naming (NiN) (*n*=3)	Unidirectional Naming (UniN) (*n*=8)	Incidental Bidirectional Naming (BiN) (*n*=3)
Sex			
Male	2	1	2
Female	1	7	1
Age	4.5	4.9	4.4
Learn Units to Criterion			
Academic programs	330	232.875	134
Derived Listener training	251.667	77.343	50
Derived Speaker training	386.667	140.416	63.33

Table 3

Correlations between UniN and BiN participants across continuous variables.

	Variable	*M*	*SD*	1	2	3	4	5	6
1	Learn Units to Criterion	232.50	84.266	____					
2	Number of Derived Speaker Training Protocol Sessions	9.07	4.196	.275	____				
3	Derived Speaker learn units to criterion	7.29	4.746	.567*	.856**	___			
4	Number of Derived Listener Training Protocol Sessions	108.389	126.679	.098	.478	.297	____		
5	Derived Listener learn units to criterion	176.667	166.320	.745**	.500	.710**	.773	____	
6	Total Number of Protocol Sessions	16.357	23.805	.161	.804**	.573*	.886**	.233	____

Means, standard deviations, and correlations (i.e., Spearman Rho)

Note. Coefficients below the diagonal represent the Spearman correlations for the total same (N=14); * correlation is significant at the 0.05 level (2-tailed), and ** correlation is significant at the 0.01 level (2-tailed)

Table 4

Acquisition of BiN Performances

Procedure Implemented	Participant	Trials to Criterion	Percentage of Listener Responses	Percentage of Speakers Responses
MEI	UniN- 1	320	100*	38
		320	90*	65
		480	95*	80**
	UniN- 2	240	100*	80**
	UniN- 3	560	100*	80**
	UniN- 4	480	90*	55
		240	100*	80**
	UniN- 5	320	90*	35
		400	80*	70
		480	90*	80**
	UniN- 6	400	70	38
		560	80*	65
		240	85*	58
		320	80*	60
Stimulus-Stimulus Pairing	UniN-6	240	100*	55
		120	100*	80**

Note: * student demonstrated Unidirectional Naming, ** student demonstrated BiN.

Table 5

Familiar stimuli used during MEI intervention

Set 1: Hey Arnold	Set 2: Power puff girls	Set 3: Rocket Power
Arnold	Bubbles	Otto
Helga	Blossom	Tito
Gerald	Buttercup	Reggie
Phoebe	Professor	Sam
Rhonda	Mayor	Twister

Table 6

Example of a MEI Learn Unit (LU) Sequence

First LU	*Second LU*	*Third LU*	*Fourth LU*
Match "A"	*Point "B"*	*Match "C"*	*Impure Tact "D"*
Tact "A"	*Intraverbal "B"*	*Intraverbal "C"*	*Match "E"*
Point "A"	*Tact "B"*	*Tact "D"*	*Intraverbal "E"*
Intraverbal "A"	*Point "C"*	*Point "D"*	*Tact " E"*
Match "B"	*Tact "C"*	*Match "D"*	*Point "E"*

Note: Table was adopted and modified from Greer, 2018, p. 21

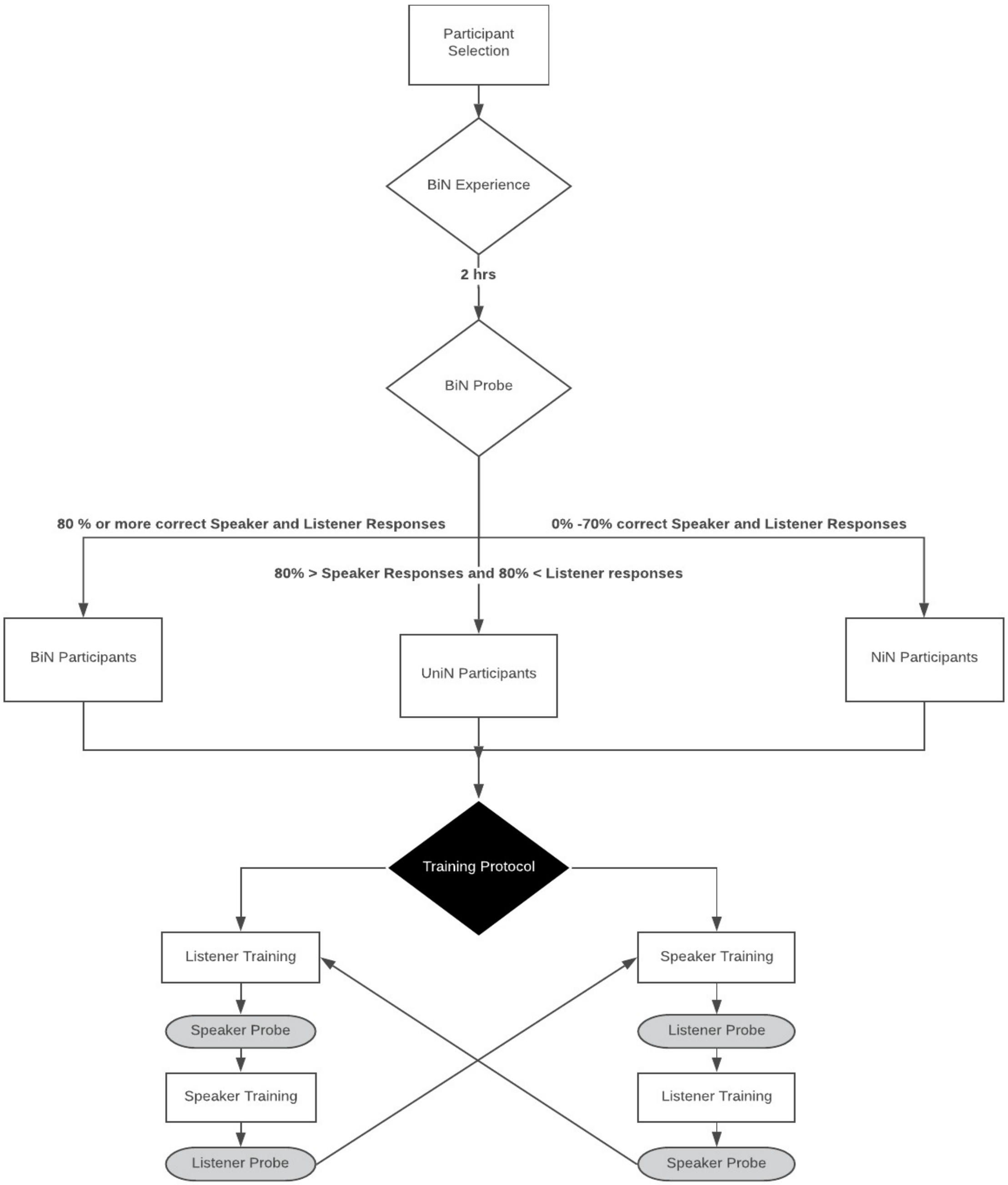

Figure 1. The experimental sequence of Experiment 1 and 2 for all participants. Level of bidirectional naming categorized (i.e., NiN, UniN, and BiN) and training protocol represented by white rectangle and derived responses represented by gray ovals.

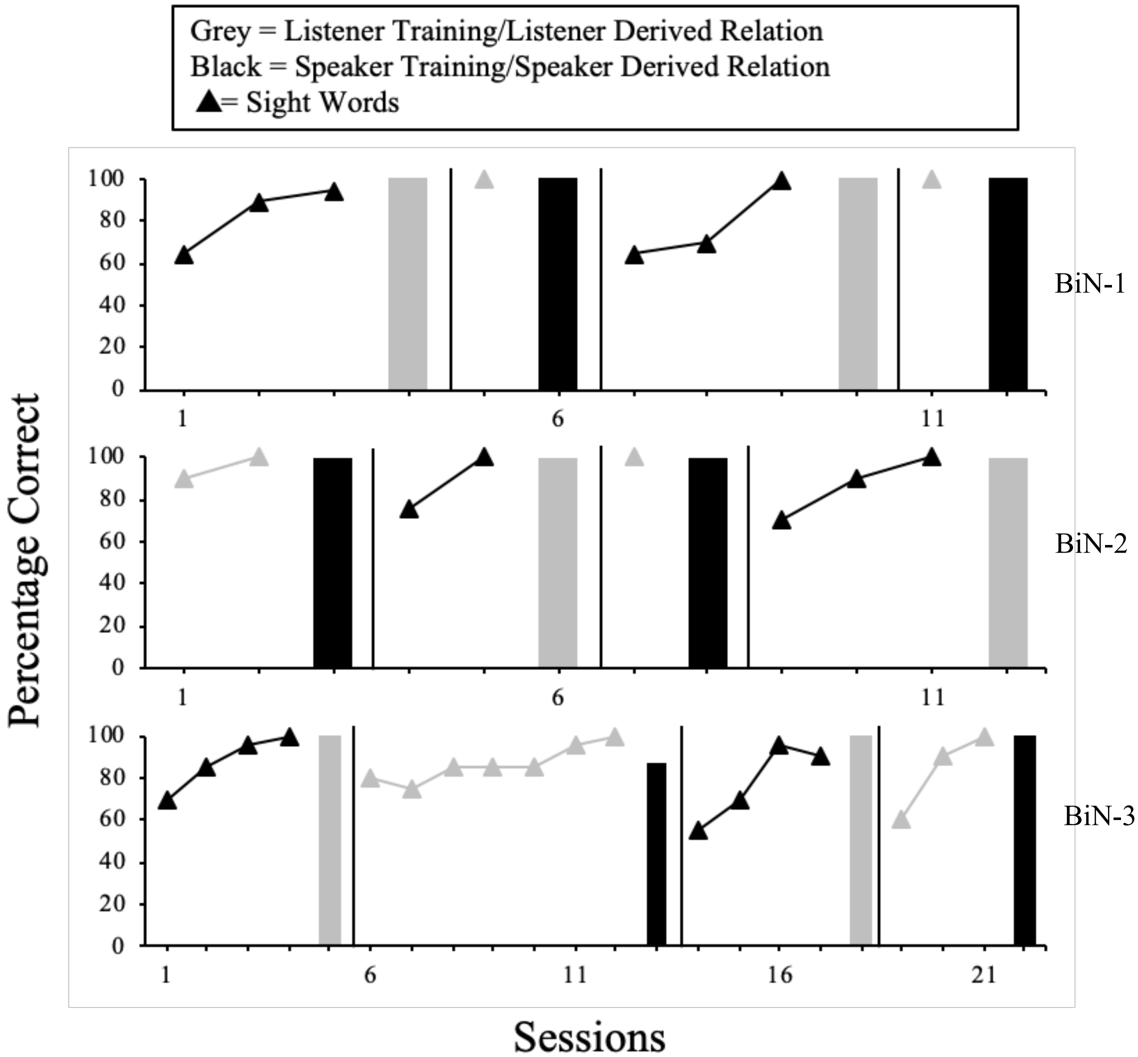

Figure 2. Training data for each BiN participant across each phase in Study 1: Experiment 1. black bars represent the derived percentage of listener response after mastering the speaker training. The grey bars represent the derived percentage of speaker response after mastering the listener training.

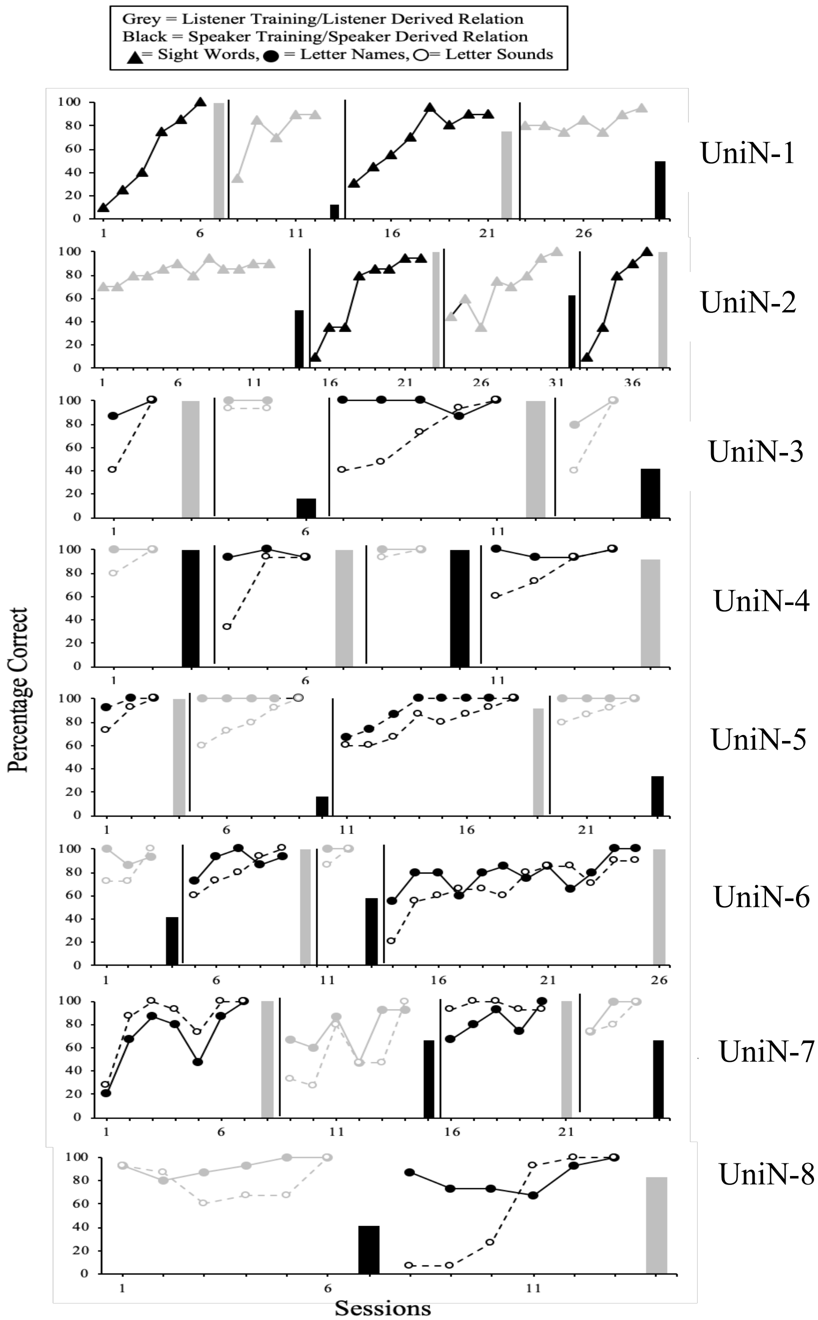

Figure 3. Training data for each UniN participants (UniN-1, UniN-1, UniN-3, UniN-4, UniN-5, UniN-6, UniN-7, and -8) in Experiment 1. Black bars represent the derived percentage of speaker responses after mastering listener trainings. The grey bars represent the derived percentage of listener response after mastering speaker trainings.

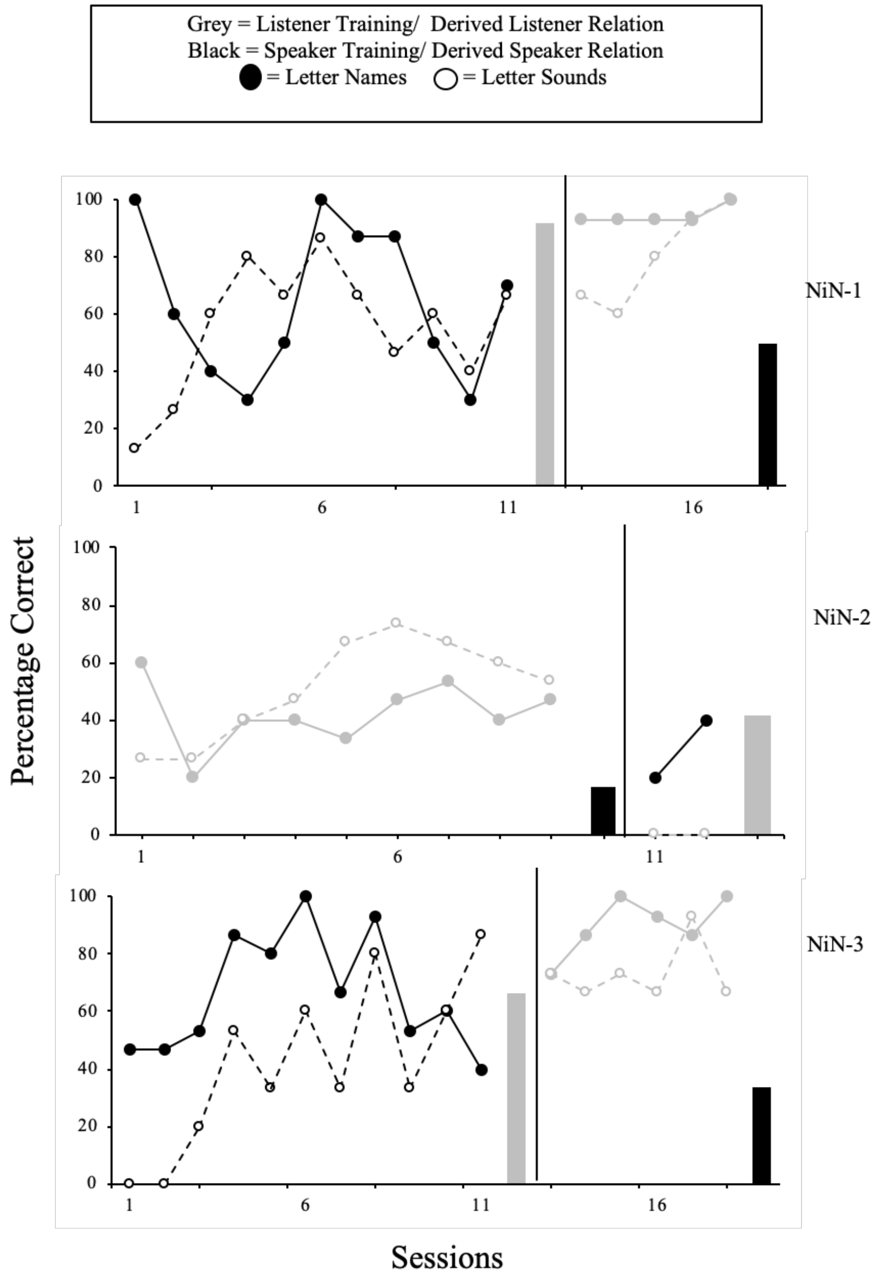

Figure 4. Training data for each three NiN participants (NiN- 1, NiN- 2, and NiN- 3) in Study 1: Experiment 1. Black bars represent the derived percentage of speaker responses after mastering listener trainings. The grey bars represent the derived percentage of listener response after mastering speaker trainings.

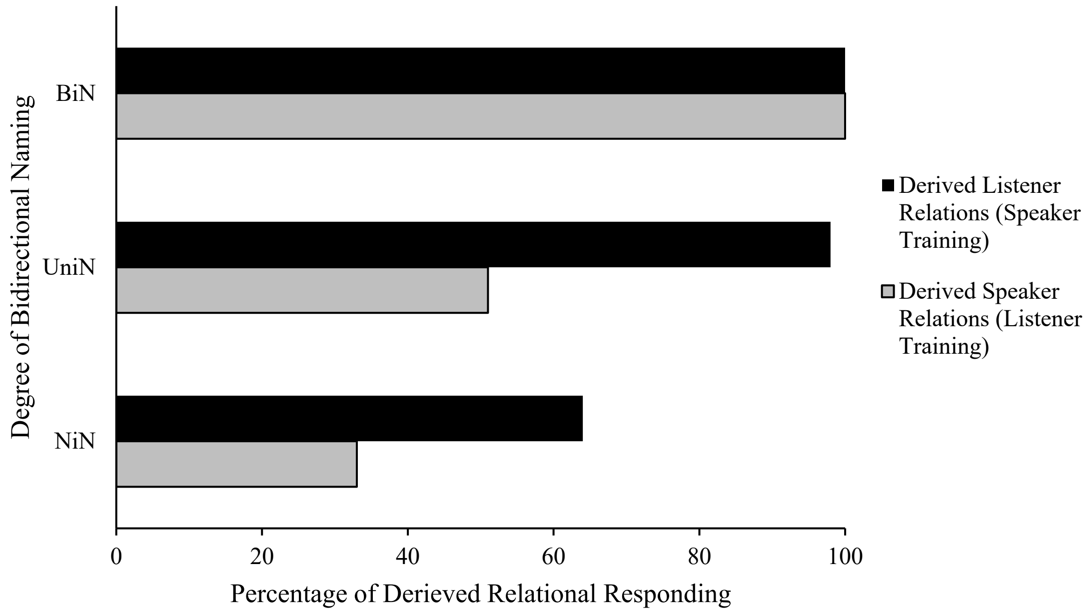

Figure 5. Percentage of derived relational responding for participants with various degrees of the Bidirectional Naming capability in Study 1: Experiment 1. BiN (n=3), UniN (n= 7), and NiN (n= 3).

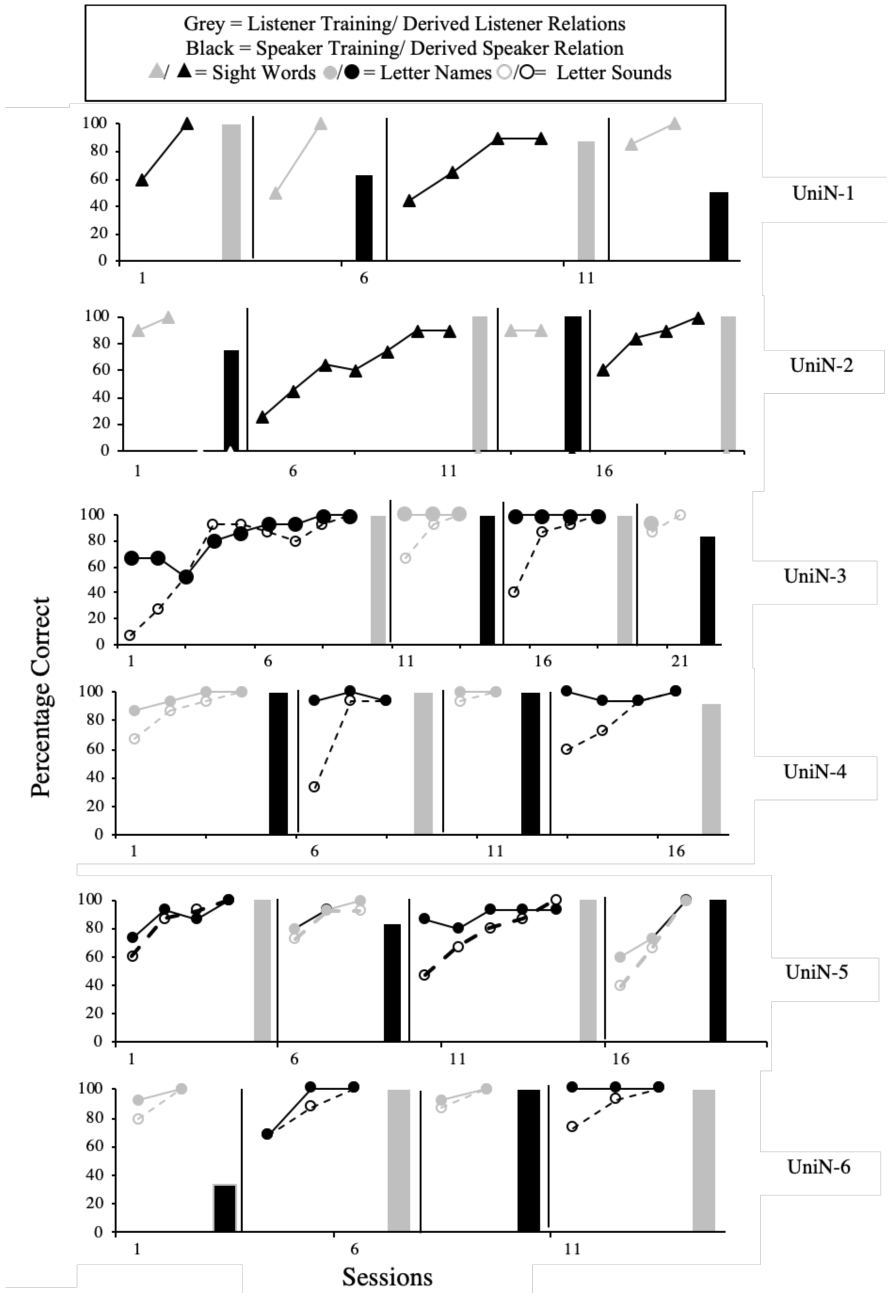

Figure 6. Training data for each UniN participants (UniN-1, UniN-1, UniN-3, UniN-4, UniN-5, and UniN-6) in Study 1: Experiment 2. Black bars represent the derived percentage of speaker responses after mastering listener trainings. The grey bars represent the derived percentage of listener responses after mastering speaker trainings.

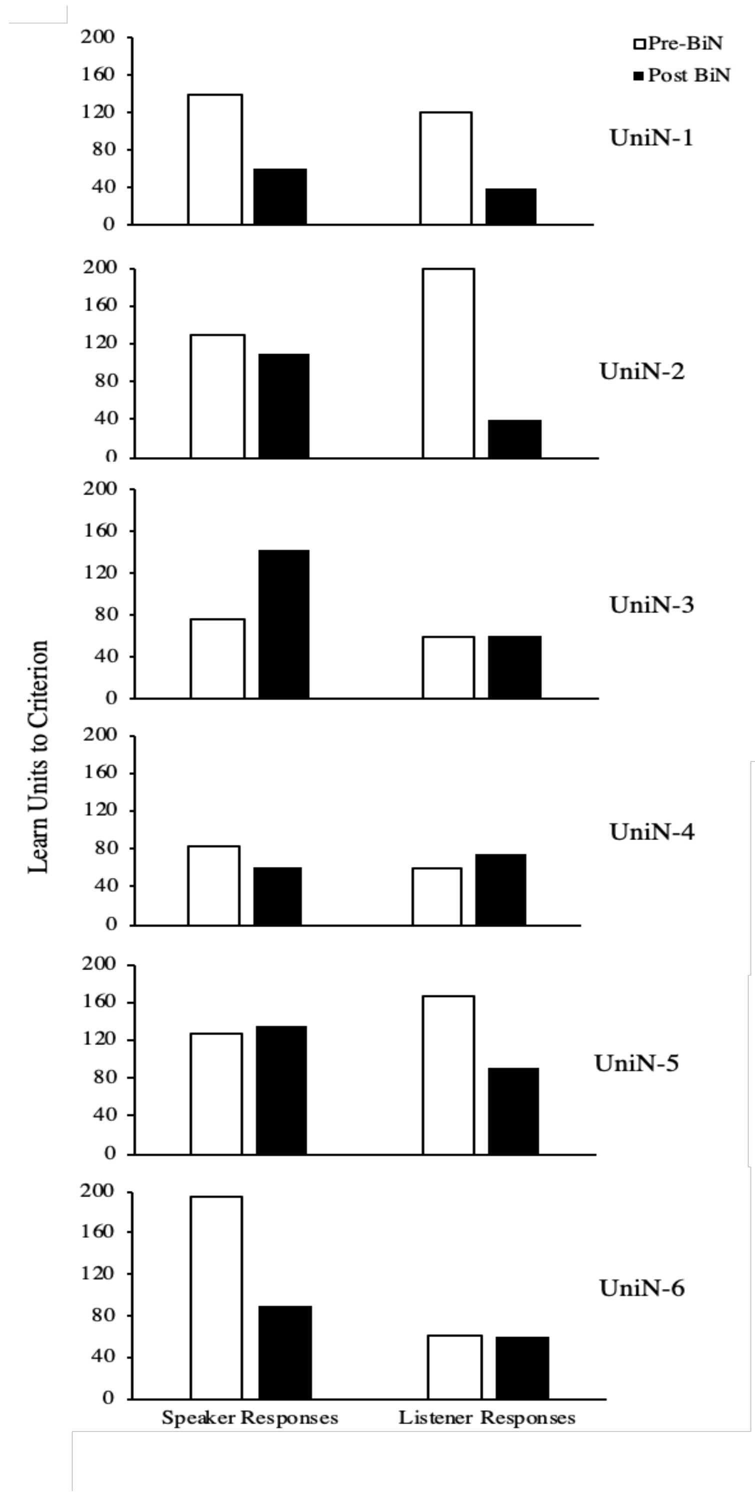

Figure 7. Learn units to criterion pre-and-post BiN in Study 1: Experiment 2. White bars represent pre-BiN and black bars represent post-BiN across derived listener and speaker responses.

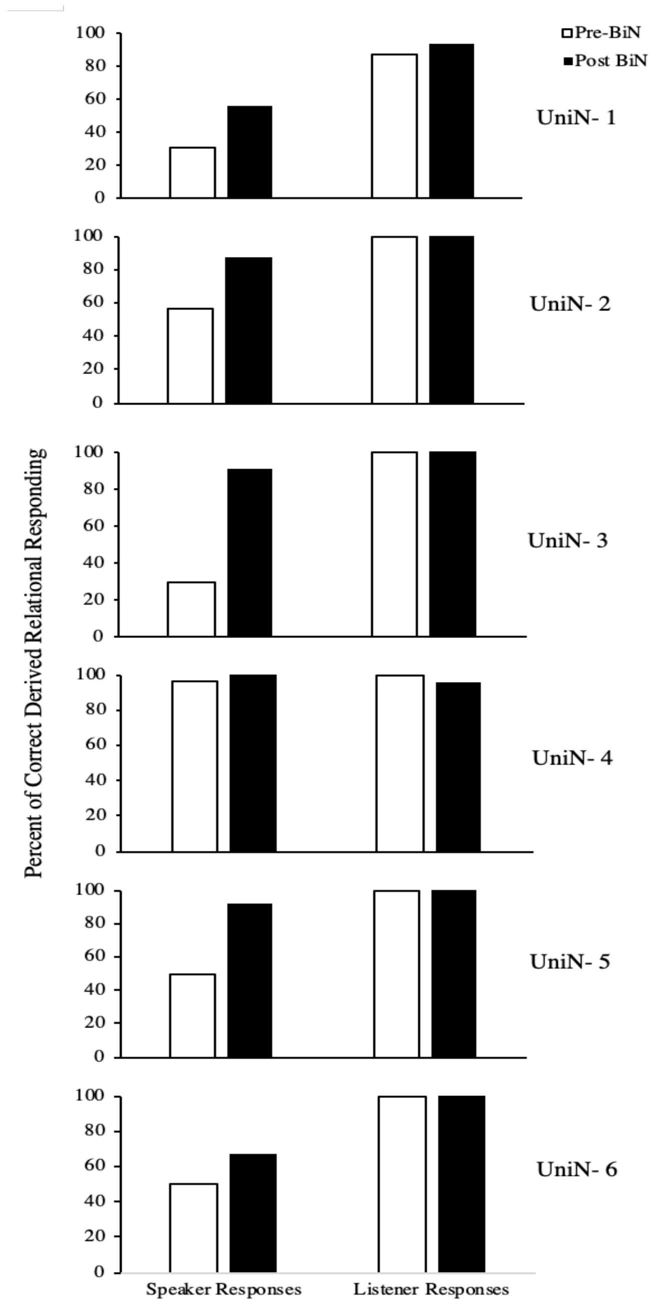

Figure 8. Percentage of derived relational responding for Participants UniN-1,2,3,4,5, and 6, pre- and post MEI in Study 1: Experiment 2. The black bar represents the percentage of correct listener responses after speaker training, and the grey bar represents the percentage of correct speaker responses after completing listener training. The dashed horizontal line depicts the predetermined criteria of 80% for derived relational responding.

CHAPTER 3: Bidirectional Naming, Derived Speaker and Listener Responses, and Equivalence Relations: A Systematic Replication

Abstract

A sizeable amount of research has been conducted on equivalence-based instruction (EBI) and the capability of bidirectional naming, respectively, but few studies have evaluated the intersection of both areas of research. We examined how the degree of bidirectional (BiN) naming correlated with children's derived relations and equivalence relations. BiN is the joining of listener and speaker repertoires such that hearing object-name relations produces corresponding speaker and listener behavior. Unidirectional naming (UniN) occurs when this experience produces listener, but not speaker behavior. In an ABAB within-subjects design, we rotated between two training conditions: 1) directly reinforcing speaker (tact) responses and testing for the emergence of listener (point to) responses, and 2) directly reinforcing listener responses and testing for the emergence of speaker responses. Results suggested that participants with BiN readily derived speaker responses, listener responses, and equivalence relations. Participants with UniN readily derived listener response and demonstrated variable responding to equivalence relations. Our results suggest ways to differentiate instruction for children with different capabilities and have implications for the overlap between verbal behavior and derived relations research areas.

Keywords: equivalence-based instruction, bidirectional naming, derived relations, unidirectional naming, stimulus equivalence

Bidirectional Naming, Derived Speaker and Listener Responses, and Equivalence Relations: A Systematic Replication

In recent decades, behavior scientists have studied the importance of generative learning, or emergent learning, to promote the efficiency and effectiveness of instruction (Rehfedlt, 2011; Critchfield & Twyman, 2014; Verdun, Chiasson, & Fienup, 2019). This resulted in a vast amount of research focused on derived relational responding, verbal behavior, and program sequencing. Specifically, researchers have focused on programming instruction to produce generative learning and understanding what conditions are necessary and sufficient to produce emergent learning (Frampton, Robinson, Conine, and Delfs, 2017; Rehfeldt, 2011; Contreras, Cooper, Kahng, 2019).

One area of research that addressed emergent learning is based on stimulus equivalence, or the formation of classes of physically distinct stimuli (Sidman, 1994). The properties of equivalence classes are categorized in three ways, reflexivity (e.g., A=A or CAT= CAT), symmetry, (e.g., A=B, then B=A or CAT= picture of cat, then picture of cat= CAT), and transitivity (e.g., if A=B and B=C then A=C or is CAT= picture of cat and picture of cat= spoken word “CAT” then CAT= spoken word “CAT”). These properties focus on the interchangeability of physically different stimuli where untaught repertories emerge through direct instruction of a subset of relations (Sidman, 1994; Piligrim, 2020; Critchfield & Fienup, 2008). An example of these emergent relations can be seen in an equivalence framework used to teach reading comprehension in adolescents with severe intellectual disabilities (Sidman & Cresson, 1973). Experimenters directly reinforced identity matching to printed words (e.g., CAT to CAT), with spoken word to picture relations (e.g. “CAT” to a picture of cat), with spoken word to printed word relations (e.g., “CAT” to print word cat). As a result, the participant demonstrated reading

comprehension by matching the written word (e.g., CAT) to the picture and vice versa. This paradigm has been applied to a number of different academic concepts, each producing generative responding after teaching a subset of relations (see reviews by Brodsky & Fienup, 2018; Raaymakers, Garcia, Cunningham, Krank, & Nemer-Kaiser, 2019; Rehfeldt, 2011).
An expansion of stimulus equivalence can be seen in equivalence-based instruction (EBI). EBI was designed with the intent to provide individuals with a way to "go beyond the information given" and broaden content information without a direct experience (Fienup & Brodsky, 2020).

Similar research has been conducted within the verbal behavior research community that focuses on the emergence of untaught listener and speaker responses with children with and without disabilities. Listener trainings, commonly referred to as conditional discriminations or receptive trainings, target gestural responses which can be seen when a child points or matches specified stimuli. Speaker trainings focus on vocal responses, such as tacts or intraverbals (Sprinkle & Miguel, 2012; Frampton et al. 2017). The empirical literature has involved teaching listener responses and testing for the emergence of corresponding speaker responses (e.g., Lee et al., 2015; Frampton et al. 2017) teaching speaker responses and testing for the emergence of corresponding listener responses (e.g., Miguel, Petursdottir, Carr & Michael, 2008; Miguel,2013) or comparing both listener and speaker trainings (Sprinkle & Miguel(2012) study described in Chapter 2 of this document). Sprinkle and Miguel found that children with autism were more likely to demonstrate the emergence of new behavior following speaker training. Thus, Sprinkle and Miguel (2012) recommend practitioners implement speaker trainings and tests for emergent listener responses, which is in line with the recommendations produce by reviews of the extant literature (Contreras, Cooper, & Kahng, 2019; Petursdottir & Devine, 2017).

Chapter 2 (Study 1, Experiments 1 and 2) of this document further examined performances of derived listener and speaker responses and how these intersect with verbal capabilities. Specifically, we studied the capability of incidental bidirectional naming, which is the joining of listener and speaker repertoires and results in children learning listener and speaker responses from antecedent presentations of object-name relations (Greer & Speckman, 2009). Study 1 (Experiments 1 and 2) found that the capacity of derived relations expands as verbal capabilities expand. These outcomes help to clarify the existing literature that demonstrates some mixed findings regarding derived listener and speaker responses. That is, Study 1 findings suggest that degrees of bidirectional naming predict the accuracy of deriving listener and speaker relations, which corresponds to correlational (Morgan 2018), conceptual (LaFrance & Tarbox, 2019; Miguel, 2018)), and experimental (Eikeseth & Smith, 1992) work in this area.

The purpose of this study was to systematically replicate the findings of Study 1 Experiment 1 (Chapter 2) and address the limitations of that study. Similar to Chapter 2, the current study utilized an ABAB within-subjects design and rotated listener and speaker trainings. Participants were randomly assigned training phases and tested after completion. Training phases were presented in the same manner as Study 1 Experiment 1, where listener trainings consisted of point to responses and speaker trainings consisted of textual/ tact responses across two target operants (i.e., picture and word). The current study controlled for some of these limitations presented in Study 1, such as standardizing instructional materials. Study 1 Experiment 1 (Chapter 2) included letter names/sounds and sight words instruction across participants, thus having inconsistent educational content where one can argue the response effort is greater in one or another. Study 2 standardized educational content to animal classes, controlling for the level of difficulty across phases. Another limitation that Study 2 addressed is the number of learn unit presentations per session. Since the educational content varied across participants in Study 1 (Chapter 2), the number of learn unit presentations varied as well. For example, sight word instruction consisted of 20 learn unit presentations measuring 4 target operants per session, whereas letter name and sound instruction consisted of 30 learn unit presentations measuring 6 targets per session. Accounting for these measurement variations skewed the comparison that could be made across learn units to criterion. Lastly, Study 2 adds the tests of equivalence which was not evaluated in Study 1 Experiment 1.

As the current study targets these limitations, the objective remained the same. We evaluated the role of verbal repertoires in other complex behaviors and tested derived relations of both untaught topographies and equivalent relations. Both speaker and listener trainings were implemented across the educational content of animal classes (e.g., mammals, reptiles, birds, and fish) and findings were correlated to the student's capability of incidental bidirectional naming. The outcomes have implications for how to differentiate instruction and capitalize on derived relations curricula as a function of the developmental repertoires and cusps, that an individual possesses. Various trainings structures were used to test for emergent learning and findings were communicated in a way to integrate the verbal communities of Verbal Behavior Development Theorists and Stimulus Equivalence researchers. Incorporating the differing theories of emergent learning can lead to a more comprehensive understanding of verbal behavior and language development (Fienup, 2019).

Methods

Participants

Eleven preschoolers (8 males) with a mean age of 4.65 (*SD* =.74) years of age at the onset of the study participated in this study. We selected participants due to the presence and absence of the BiN capability in their verbal repertoire (BiN assessment described below). None of the participants had a history of exposure to derived relations research. Each participant received educational services at a private behavior analytic preschool utilizing the Comprehensive Application of Behavior Analysis (CABAS®) model (Greer, 2002). At the school, educators determined curricula and assessed the presence of developmental cusps via the Preschool Inventory of Repertoires for Kindergarten (C-PIRK®, Greer & McCorkle, 2009). As per this assessment, all 11 participants demonstrated repertoires of reliably attending to instructors voices, faces, and instructional stimuli. All students in the study had an Individualized Education Plan (IEP) and were diagnosed as a "preschooler with a disability" and received related services, and 42% (n=3) previously attended a behavior analytic Early Intervention (EI) program.

Six participant's performances met the criterion for BiN (criterion on listener and speaker responses). These participants had large verbal repertoires and could vocally mand and tact a variety of items. Each completed academic programming that included reading instruction and beginning-level math skills (e.g., one-to-one correspondence and the concept of more or less). Participant BiN-1 was a 4.7.-year-old female and attended school for approximately 1.5 years. Participant BiN-2 was a 5.6 -year-old male attended school for approximately two years. Participant BiN-3 was a 5.6.-year-old male and attended school for approximately 2.5 years, and Participant BiN-4 was a 5.3-year-old male and attended school for approximately 2.5 years. Participant BiN-5 was a 3.5-year-old male and attended school for approximately 1.5 years and Participant BiN-6 was a 4.7-year-old male and attended school for approximately 2 years.

Five participant's performances met the criterion for UniN (criterion on listener responses, but not speaker responses). These participants had moderate verbal repertoires and could vocally mand and tact a variety of items. At times, these participants gestured to mand, instead of vocalizing mands in novel situations. Each completed academic programming that included pre-reading skills (e.g., textually responding to letter name and sound) and beginning-level math skills (e.g., number identification). Participant Uni-1 was a 5.2.-year-old male and attended school for approximately 1.25 years. Participant UniN-2 was a 3.9 -year-old male attended school for approximately 1.25 years. Participant UniN-3 was a 4.3-year-old female and attended school for approximately 2 years. Participant UniN-4 was a 4.7-year-old female and attended school for approximately 2 years and Participant UniN-5 was a 3.7-year-old male and attended school for approximately 1 year.

Settings and Materials

All sessions were conducted in the participants' respective classrooms. During all sessions, the participant sat next to the researcher at a U-shaped table. During bidirectional naming experience, the researcher presented two-dimensional (74 by 105 mm index cards) familiar stimuli (e.g., gemstones– "ruby, jade, onyx, sapphire, diamond) of 2D images presented on 74 x 105 mm index cards.

During the respective trainings and testing sessions for animal species for four 3-member classes were taught. Each 3-member class consisted of the vocal target (e.g., "aardvark", which served as stimulus A, the written word of the target stimuli which served as stimulus B, and the picture of the target stimuli which served as stimulus C (see Table 1). Each stimulus measured 3.81 by 3.175 mm and was presented on a 3.32 mm screen. The researcher presented stimuli on a MacBook Pro laptop with a 332 mm display. A Microsoft © PowerPoint® presentation was used where a match to sample procedure was implemented (i.e., target stimuli was presented at the top of the screen) and examples of non-target stimuli were presented at the bottom of the screen in a field of 5. All stimuli presented measured 6.72 mm by 5.98 mm.

Measurement

Bidirectional naming experience. The BiN assessment (identical to Study 1 Experiment 1, discussed in Chapter 2) was composed of two components, exposure to name-object relations and assessment of corresponding listener and speaker. During the exposure phase, the researcher measured match respones. During the BiN assessment, the researcher measured corresponding speaker (pure and impure tacts) and listener (point to) responses. For point to responses, three stimuli were presented in a horizontal array (two non- exemplars and one target exemplar) with the vocal antecedent of "point to". For tact and intraverbal responses, stimuli were presented in random order ensuring that target stimuli were not presented consecutively. Correct responses were those that corresponded to the discriminative stimulus and were emitted within 5 s of the discriminative stimulus. Incorrect responses were those that did not correspond to the discriminative stimulus or no response within 5 s. The assessment of each topography included 20 unconsequated LU opportunities and we calculated the percentage correct as number of correct LUs divided by 20 and multiplied by 100.

Equivalence-based instruction. During the teaching portion of EBI, the researcher measured the accuracy of listener and speaker responses and calculated on the mean number of learn units to criterion across listener and speaker training protocols. The mean number of learn units to criterion (i.e., LUC) was calculated by adding the total number of learn units presented and divided by the number of objectives achieved. This was calculated as the total number of learn units presented during each training protocol and then divided by 2 (i.e., the number of objectives achieved per condition).

During the testing portion of EBI, the researcher measured the accuracy of derived relations. We measured two topographies of symmetry: speaker and listener responses. We also measure derived equivalence relations. We measured derived relations in accordance with which repertoire was reinforced (i.e., measurement of speaker responses following listener training and measurement of listener responses following speaker training. A correct response was one that corresponded to the discriminative stimulus and was emitted within 3 s. For example, if the discriminative stimulus were a picture of a fennec fox, pointing to a picture of a Fennec Fox was considered a correct derived listener response and stating "Fennec Fox" was considered a correct derived speaker response. An incorrect response was one that did not correspond to the discriminative stimulus or no response within 3 s.

During EBI training the researcher administered 15 learn units (i.e., LUs), or learning trials, per session that included 5 learn units of each of the three target responses presented in a randomized order. At the end of the session number of correct responses were totaled and graphed as a percentage. The number of correct responses were divided by the total number of opportunities presented then converted into a percentage (i.e. 5/15 * 100= 33%). Sessions were graphed and plotted on a percentage graph.

Independent Variable

We evaluated two independent variables in this study. First, for each participant, we rotated between two training and derived relations conditions: 1) in the listener training, we directly reinforced listener responses and tested for the emergence of related speaker responses. 2) in the speaker training, we directly reinforced speaker (tact) responses and tested for the emergence of related listener (point to conditional discriminations) responses.

Second, we examined derived relations performances according to categories of bidirectional naming that participant demonstrated at the start of the experiment. All participants were exposed to object-name relations and were assessed for corresponding speaker and listener responses 2-hr later. Participants who scored 80% or higher on speaker and listener responses were categorizes as having BiN. Participants who scored 80% or higher on listener responses, but below 80% on speaker responses were categorized as UniN.

Procedure

Participants were first categorized by degrees of bidirectional naming (i.e., UniN or BiN) then selected to complete a training protocol; selection was randomized. Below describes each component in detail.

BiN-assessments. The BiN assessment was composed of two components, exposure to name-object relations and assessment of corresponding speaker and listener responses. During the exposure, the researcher obtained the participant's attention, provided identity matching trials, named the stimulus during the trials, and provided consequences contingent on the participant's match response (not contingent on responses in accordance with the name, such as an echoic). At the start of each trial, the researcher laid out three stimuli in front of the participant (two non- target exemplars and the target stimuli), presented the participant with the target exemplar and the antecedent "match ____ to _____" (e.g., "Match ruby to ruby"). Contingent upon a correct matching response, the researcher praised the participant's response and provided playful physical contact. If the participant matched the target stimulus to a non-exemplar or did not respond within 3 s, the researcher implemented a correction procedure whereby she modeled the correct matching response to the participant and represented the antecedent to allow the participant the opportunity to independently respond. Each session was composed of 20 match responses (5 stimuli with four trials per stimulus). BiN exposure sessions were continued until a participant responded with 90% accuracy during two consecutive sessions. It is important to note that contingencies were arranged for matching stimuli, not for verbal behavior (e.g., echoics) related to the experimenter naming the stimulus.

The second component of the BiN assessment was a test for corresponding speaker and listener responses. After the BiN exposure, the researcher assessed corresponding listener and speaker responses 2 hr later. Three responses were measured. The researcher assessed listener responses by presenting the participant with three stimuli (two non-exemplars and one target stimulus) and the vocal direction "Point to _____". For speaker responses, the researcher assessed pure and impure tacts. For pure tacts, the researcher held one stimulus in front of the participant and waited up to 5 s for the participant to provide the corresponding tact (name). For impure tacts, the researcher conducted trials similar to pure tact trials and added the vocal direction, "What is this?" The researcher conducted 20 trials for each response type (point to, pure tact, impure tact), which was composed of 4 opportunities to respond to each of 5 stimuli. During this probe for listener and speaker responses, the researcher provided no accuracy feedback, but intermittently praised academically related behaviors such as sitting and attending.

Equivalence-Based Instruction. The researcher used two training protocols; speaker training and listener training to train baseline relations and test for the emergence of derived relations (see Figure 1). Training phases were conducted as learn unit instruction (Albers & Greer, 1991). Upon emitting a correct response, the researcher delivered vocal praise, playful physical contact, or a token. The researcher engaged in a correction procedure contingent on incorrect responses. During derived relations phases, the researcher provided no feedback students received two opportunities to response per operant per topography.

Equivalence test. The researcher started by pre-testing the participants on the matching equivalent relations (i.e., B→ C and C→B relations). At the onset of the study, participants were tested on all the animal classes in order to ensure the responses were not already in a participant's repertoire. During the pre-test, one sample stimulus was presented at the top of the screen and five were presented at the bottom in a horizontal fashion, with the presentations of one positive exemplar, and five negative exemplars within the same animal class). The participants were instructed to "Match". The researcher recorded the first comparison stimulus touched by the participant. This was conducted independent of training type. For the pretest and all other tests, no consequences were delivered for correct or incorrect response. The pretest consisted of 12 trials. There were 6 B →C relations and 6 C→ B relations across each stimulus class.

Pretests. A test for all possible relations were conducted at the onset of each training condition, this composed of 24 trials; 4 relations (2 symmetry and 2 equivalence). Equivalence tests were identical to the pre-test where the BC and CB relations were tested (i.e., that is matching word to picture and picture to word)

Listener training. During listener trainings, given stimuli ABC, the researcher 1) taught AB and AC relations using learn unit instruction, 2) tested for the emergence of the symmetry relations BA and CA, and 3) tested for the emergence of BC and CB equivalence relations (Fienup & Brodsky, 2020). For example, in the case of Figure 1, the participant was taught to point the word caribou (stimulus B) and point to a picture of a caribou (stimulus C) in the presence of the spoken name "Caribou" (stimulus A). The test of symmetry included tacting the picture of a caribou and textually responding to the word caribou. The test of equivalence involved matching a picture of a caribou to the word caribou and vice versa. caribou).

During listener training, the participant received 15 opportunities to point to written word (stimulus B) and picture of target stimuli (stimulus C), for a total of 30 trials. The criterion for each response was 90% accuracy for two consecutive sessions or 100% accuracy across one session. During each session, the researcher presented an array of five stimuli, one target exemplar and four non-target exemplars. After presenting the comparison stimuli, the researcher presented the vocal antecedent (e.g., "point to caribou") and allowed 3 s for the participant to respond. If the participant pointed to the target exemplar, the researcher provided potentially reinforcing consequences (i.e. vocal praise, playful physical contact, tokens). If the participants emitted an incorrect response (i.e. pointing to a non-target exemplar or no response), the researcher implemented a correction procedure. For the correction procedure, the researcher modeled the correct response (i.e. pointed to the target stimulus), and 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 researcher modeled the response up to 3 times before proceeding to the next learn unit.

After a participant's responding met mastery criterion during the listener training teaching portion, the researcher assessed derived speaker responses. The researcher held up each 2D stimulus, said, "What animal is this/What does this say?", and waited 3 - 5 s for the participant to respond. There were 12 trials in a session, which was composed of three stimuli, two responses (e.g., tacting animal when presented with picture/word), and two opportunities of each trial type. Criterion for the demonstration of the derived relational responding was 80% accuracy in one session[2].

[2] It is common practice to select 90% as criterion to demonstrate mastery of derived relations, but in this case 80% was selected due to the number of opportunities presented (i.e., totaling 6). The student could emit one error (83%) and is still said to have derived relational responding.

Speaker training. During speaker trainings the experimenter taught the BA and CA relation using the learn unit and tested for the emergence of the symmetric relations AB and CA and the equivalence relation of BC and CB (Fienup & Brodsky, 2020). For example, in the case of Figure 1, the participant was taught to textually respond to the word caribou (stimulus B) and tact the picture caribou (stimulus C), and then tested to on the emergence of the untaught relation of pointing to the word caribou and pointing the picture of caribou. This training consisted of teaching the participant to emit vocal responses to 2D stimuli, followed by tests of the emergence of corresponding listener responses. This training phase consisted of two experimentally defined responses (i.e. picture of target stimuli and written word). For each session, instruction was presented in a rotated sequence. The participant received 15 opportunities to textually respond to "Read the word/what does this say" and 15 opportunities to intraverbal tact response of (i.e. "What animal is this?"), for a total of 30 massed trials. The criterion for each response was 90% accuracy for two consecutive sessions or 100% accuracy across one session. Data were collected and recorded in the same manner as stated above.

After each speaker training sessions, participants were assessed on the untaught topography. The researcher presented an array of five stimuli, one target exemplar and four non-target exemplars, which included other animals within the same class. After presenting the stimuli, the researcher presented the vocal antecedent (e.g., "point to caribou") and the participant was given 3 s respond. Criterion for the demonstration of the derived relational responding was 80% accuracy across one session.

Procedural Modifications

Decision to stop protocol. The same decision protocol utilized in Experiment 1 (Study 1) was used. The researcher modified portions of protocols contingent upon mastering the respective protocol. Data from the training sessions were analyzed using the CABAS® Decision Protocol (Keohane & Greer, 2005). We implemented the decision protocol as an ethical guard against keeping participants in a training phase when additional instructional supports were needed. Additional tactics were not implemented due to the selected participants performance data.

Experimental Design

The researchers implemented a counterbalanced ABAB within-subjects design (Baer, Wolf & Risley, 1968) across participants to test the effects of direct instruction on one topography on the emergence of the derived responses. Additionally, trainings were counterbalanced across participants. For example, Participant BiN-1 started with the speaker training phase while Participant BiN-2 started with the MTO phase. Each participant progressed through the respective conditions (OTM or MTO) at their own pace until mastery was met in each condition and the participant rotated through each condition two times, for a total of four conditions. The researcher conducted tests for derived relations immediately following mastery of the respective relations.

Results

Performance During Listener and Speaker Trainings

Each participant completed speaker and listener trainings and tests for untaught, derived relations. Below we categorize outcomes by level of BiN at the start of the study. Figures 2 and 3 display the training and derived relations data for participants with BiN and UniN, respectively. When participants were directly instructed using the speaker training procedure the researcher measured the derived relational responding as a listener and vice versa for the listener training procedure. In each graph, all listener responses grey, such that the light grey data points represent listener trainings and grey bars represent derived listener responses. All speaker responses are black, such that black data points represent speaker training and black bars represent derived speaker responses. During the pretest of emergent relations (see Figure 2 and Figure 3 (represented by the downward arrows), all participants scored “0”. During tests of equivalence, participants matched pictures to printed words and vice versa (relations CB and BC represented by the dark gray bars and the diagonal striped bars, respectively).

Participants with UniN. Figure 2 displays the training and derived relations data for 5 UniN participants. All UniN participants steadily achieved mastery criterion during the respective trainings. Participant UniN-1 learned speaker responses in 120 LUs (4 sessions) and derived listener responses with an average of 96% accuracy (range 92% to 100%). UniN-1 learned listener responses in and average of 180 LUs (6 sessions) and derived speaker responses with an average of 66% accuracy (range = 58% to 75%). Participant UniN-1 derived CB relation with an average of 45% accuracy and the BC relation with 54% accuracy. Participant UniN-2 learned speaker responses in an average of 180 LUs (6 sessions) and derived listener responses with an average 92% accuracy (range= 83% to 100%). UniN-2 learned listener responses in an average of 135 LUs (4.5 sessions) and derived speaker responses with an average of 50% accuracy (range = 0%to 100%. Participant UniN-2 derived CB relation with an average of 67% accuracy and the BC relation with 75% accuracy. Participant UniN-3 learned speaker responses in an average of 165 LUs (5.5 sessions) for both sets and derived listener responses with an average of 96% accuracy (range = 92% to 100%). UniN-3 learned listener responses in an average of 180 LUs (6 sessions) and derived speaker responses with an average 46% (range = 33% to 50%) accuracy. Participant UniN-3 derived CB relation with an average of 67% accuracy and the BC relation with 62% accuracy. Participant UniN-4 learned speaker responses in an average of 135 LUs (4.5 sessions) and derived listener responses with an average of 96% accuracy (range = 92% to 100%). UniN-4 learned listener responses in an average of 135 LUs (4.5 sessions) and derived speaker responses with 38% accuracy (range = 25% to 50%). Participant UniN-4 derived CB relation with an average of 79% accuracy and the BC relation with 83% accuracy. Participant UniN-5 learned speaker responses in an average of 345 LUs (11.5 sessions) and derived listener responses with an average of 62.5% accuracy (range = 58% to 67%). UniN-5 learned listener responses in an average of 225 LUs (7.5 sessions) and derived speaker responses with an average 71% accuracy (range =66% to 75%) accuracy. Participant UniN-5 derived CB relation with an average of 42% accuracy and the BC relation with 54% accuracy.

Overall, UniN participants readily acquired speaker responses under direct reinforcement contingencies and derived corresponding listener responses, but were unable to derive speaker responses under listener trainings.

Participants with BiN. Figure 3 displays the training and derived relations data for 6 BiN participants. All BiN participants achieved mastery criterion during the respective trainings and met criterion levels during all derived relations probes. All 6 participants demonstrated the immediate emergence of equivalence classes on the 3Mix test independent of the training condition. In addition, all BiN participants derived the untaught topography with little to no errors, where each derived relational probe included two learn units of topography. Participant BiN-1 learned speaker responses in an average of 105 LUs (3.5 sessions) and derived listener responses with 100% accuracy for both sets. BiN-1 learned listener responses in and average of 75 LUs (2.5 sessions and derived speaker responses with an average of 100% accuracy for both sets. Participant BiN-2 learned speaker responses in an average of 120 LUs (4 sessions) and derived listener responses with an average of 92% accuracy (range = 83% to 100%. BiN-2 learned listener responses in an average of 135 LUs (4.5 sessions) and derived speaker responses with an average of 63% accuracy (range = 50% to 75%). Participant BiN-3 learned speaker responses in an average of 60 LUs (2 sessions) and derived listener responses with 100% accuracy for both sets. BiN-3 learned listener responses in an average of 105 LUs (3.5 sessions) and derived speaker responses with 100% accuracy for both sets. Participant BiN-4 learned speaker responses in an average of 75 LUs (2.5 sessions) and derived listener responses with 100% accuracy for both sets. BiN-4 learned listener responses in an average of 90 LUs (3 sessions) and derived speaker responses with 100% accuracy for both sets. Participant BiN-5 learned speaker responses in an average of 90 LUs (3 sessions) and derived listener responses with 100% accuracy for both sets. BiN-5 learned listener responses in an average of 150 LUs (5 sessions) and derived speaker responses with 100% accuracy for both sets. Participant BiN-6 learned speaker responses in an average of 90 LUs (3 sessions) and derived listener responses with 100% accuracy for both sets. BiN-6 learned listener responses in an average of 90 LUs (3 sessions) and derived speaker responses with 100% accuracy both sets. Overall, BiN participants readily acquired speaker and listener responses under direct reinforcement contingencies and derived corresponding listener and speaker responses.

After the completion of listener/MTO training where B→ A and C→A relations were directly taught, participants were then tested using the 3Mix test (i.e., A→,B, A→C, B→C, and C→B). Participant BiN-1, Participant BiN-3, and Participant BiN-6 all derived transitive relations; resulting in the emergence of the C→B and B→C relations with 100% accuracy. Participant BiN-2 and Participant BiN-5 derived these relations with 92% accuracy. Participant BiN-4 derived these relations with 95% accuracy After the completion of speaker/OTM training, where A→B and A→C relations were directly taught, participants were tested using the 3Mix (see above). Participant BiN-3 and Participant BiN-6 both demonstrated transitivity with 100% accuracy. Participant BiN-1 and Participant BiN-4 both demonstrated transitivity with 98% accuracy (95% to 100%). Participant BiN- 3 demonstrated transitive relation with

Outcomes According to Degree of Bidirectional Naming

Learn Units to Criterion. Figure 4 displays the overall number of learn units to criterion, as well as the number of learn units to master both listener and speaker training responses grouped by degrees of bidirectional naming. UniN participants had a higher average of overall learn units to criterion (*M*=85.87, *SD* = 34.33) than BiN participants (*M*=43.44, *SD*=8.82). UniN participants had an average of 86 (SD= 15.14) and 85.5 (14.55) learn units to criterion across speaker and listener training, respectively. Whereas, BiN participants average of 41 (SD= 15.06) and 46 (3.4) learn units to criterion across speaker and listener training, respectively. An independent-samples t-test was conducted to compare the differences among the degree bi-directional in terms of learn units to criterion (i.e., LUC). There was a statistically significant difference between UniN participants and BiN participants in the overall number of learn units to criterion, t (9) =2.94, p=.016. It also revealed that there was a statistically significant difference between the degree of bi-directional naming and the learn units across both listener training, t (9) =2.51, p=.034 and speaker training, t (9) =3.12, p=.012. After completing the listener training, UniN participants had a higher number of learn units to criterion (*M*=85.5, *SD* = 36.49) than BiN participants (*M*=46.25, *SD*=11.77). Similarly, after completing the speaker training, UniN participants had a higher number of learn units to criterion (*M*=86.25, *SD* = 24.57) than BiN participants (*M*=40.63, *SD*=9.61). Specifically, our results suggest that BiN participants learn at half the rate of their UniNcounterparts.

Overall, participants who demonstrated BiN learned at a faster rate, regardless of training, whereas participants who demonstrated UniN needed twice the number of opportunities in order to master the objectives. The current analysis supports previous research, which have demonstrated that students with BiN learn at a faster rate and require fewer learn units to meet criterion (Greer & Longano, 2010; Hranchuk, Greer, & Longano, 2019; Greer, Corwin, & Buttigieg, 2011). As our results show, BiN participants required fewer learn units to meet criterion than those with UniN. Additionally, participants with UniN were able to benefit from speaker training, as they emitted a lower number of learn units to criterion.

Derived Relations. Figure 5 displays the percentage of derived speaker and listener responses grouped by degrees of bidirectional naming. Overall, participants who demonstrated BiN were able to derived the untaught topography, regardless of training, whereas participants who demonstrated UniN they were able to derive 88% of the listener responses (following speaker training) and 54% of the speaker responses (following listener training).

We compared the percentage of derived relational responding to listener and speaker training probes, (i.e., listener and speaker, respectively) across the different degrees of bi-directional naming. An independent-samples t-test was conducted to compare the differences among the degree bidirectional in terms of percentage of derived relational responding. There was a statistically significant difference between UniN participants and BiN participants in derived relational responses as a speaker (after completing listener training), t (9) =- 4.16, p=.002. After completing the listener training, UniN participants (M=54.99, SD = 15.13) derived speaker responses less than BiN participants (M=93.05, SD=15.06). Conversely, there was not a statistically significant difference in derived relational responses as a listener (after speaker training) t (9) =- 1.69, p = 0.124. After completing the speaker training, UniN participants

(*M*=88.21, *SD* = 14.54) derived listener responses at a similar percentage as BiN participants (*M*=98.61, *SD*=3.4).

We compared the percentage of symmetric and transitive relations, C → B and B→C after the completion of listener and speaker training protocols across the different degrees of bi-directional naming. An independent-samples t-test was conducted to compare the differences among the degree bi-directional in terms of class formation. There was a statistically significant difference between UniN participants and BiN participants in the C→B relation, *t* (9) =-4.93, *p*=0.005 and the B → C relation, *t* (9) =-5.00, *p* = 0.004. Overall, participants with UniN did not demonstrate the C → B relation, (*M*=59.96, *SD* = 15.80) whereas participants with BiN demonstrated this emergence (*M*=96.52, *SD* = 5.53). Furthermore, participants with UniN did not demonstrate the B → C relation, (*M*=65.83, *SD* = 12.98) whereas participants with BiN demonstrated this emergence (*M*=96.53, *SD* = 4.87). Figure 7 displays the overall class formation across degrees of bidirectional naming, there is a 37.46 percent difference in those participants who participants with BiN than those with UniN in the C → B relation. Similarly, there is a 30.7 percent difference in the B→C relation, in those participants with BiN than those with UniN.

Discussion

As verbal behavior research expands, so does its branches of integration across verbal behavior camps (Fienup, 2018; Pettursdottir & Devine, 2017). The current study extends on the previous findings of Sprinkle and Miguel (2012) and Study 1 (see Chapter 2) and incorporate the verbal behavior measure of bidirectional naming and a generic EBI procedure. The outcomes of the study suggest commonalities among bidirectional naming and derived relations. These results have implications for how to differentiate instruction and capitalize on derived relations curricula as a function of the developmental repertoires, or cusps, that an individual possesses. The findings demonstrate that students with the BiN capability, acquire skills as a faster rate than those with UniN and derive relations with higher accuracy across untaught topographies, symmetric and transitive relations. Integrating verbal behavior literature with derived relations literature allow strategic scientists to not only individualize and differentiate instruction but maximize emergent learning.

Both speaker and listener trainings were used to test emergent responding across UniN and BiN participants. Results indicate that the speaker training protocol was superior in producing derived relations and equivalence relations across both groups of participants. All 5 UniN participants did not demonstrate the immediate emergence of equivalence classes or derived speaker relations following listener training. Whereas, 3 of the 5 UniN participants demonstrated the immediate emergence of equivalence classes after the completion of the speaker training. The current findings suggest that it should be considered first when presenting instruction for those with developmental disabilities.

The outcomes of this study replicate and clarify previous findings, especially those found in Study 1. Similar to Lee et al. (2015) and Sprinkle and Miguel (2012) we observed that speaker trainings were more effective in producing emergent responding than listener trainings, for both UniN and BiN participants. Furthermore, it clarifies the outcomes of previous research, such as Eikeseth and Smith (1992), suggesting that the degrees of BiN can, in fact, predict derived relations. The data thus far demonstrate a correlation between the degrees of bidirectional naming (specifically UniN and BiN) and derived relations. The current study addressed limitations presented in Study 1 (see Chapter 2), specifically that of educational content and standardizing the number of learn unit presentations per session. Adjusting these limitations strengthened this studies' internal validity by employing a consistent measurement procedure (e.g., all participants were exposed to 30 learn units per session and educational content).

Previous literature in verbal behavior development have focused on derived relations as a collateral effect of transformation of stimulus functions, or to put more simply when a single stimulus can control two different responses topographies (Greer & Ross, 2008). This cusp is said to be present when a student is exposed to multiple exemplar experiences, this can be seen in the current study when participants learned as both a listener and speaker.

This study has practical implications for instructional design, it extends previous findings by examining symmetry and equivalence relations in students with varying degrees of bidirectional naming. The data suggest that participants with the BiN capability derived relations at a faster and in a more accurate way. Although, Greer and Speckman (2009) highlight the verbal behavior develop trajectory, it is important for classroom teachers to assess each student on their capabilities in order to make informed decisions about the student's programming. Educators are encouraged to take on the role of a strategic scientist and identify the underlying pedagogical relations between teachers and student performances (Greer, 2018). It is through strategic tools of pedagogy that an educator can employ learner specific strategies that maximize instruction based on a student's verbal repertoire, specifically their cusps and capabilities or their pivotal skills.

The general findings are similar across both Study 1 (Chapter 2) and Study 2 (this Chapter), participants with the BiN capability can learn tacts from antecedents (i.e., learning tacts from pairings of name-object relations during listener training and then the emergence of derived speaker responses). Whereas, participants with UniN capability cannot learn tacts from antecedents, which is why they fail the tests of derived speaker responses. Such findings correspond with the VBDT that suggest listener behavior is first acquired before speaker trainings, similar to the concept of learning to crawl before walking.

This study contained limitations and raise issues to be addressed in future research. First, the sample size was small due to the limited student population at the selected site. Future studies should increase sample size across the degrees of bidirectional naming. Second, researchers should obtain more IOA and fidelity. Third, a 3Mix should have been conducted at the end of the study, and maintenance should have been evaluated. Last, in the current studies participants were tested for BiN once (i.e., at the onset of the study) then categorized, future studies should conduct a minimum of two naming experiences across both familiar and unfamiliar stimuli, this will assist in generalization of results.

As the field of applied behavior analysis expands so does the overlap in perspectives. In the camp of verbal behavior an overlap exists between the stimulus equivalence and relational frame theorists. We know that the future of verbal behavior research is integration and as we grow as a field it is imperative that we understand the various perspectives (Fienup, 2019). Developing an understanding of each respective field sets the foundation for understanding the complexities of verbal behavior. While little to no experiments studied the intersection of verbal behavior measures of bidirectional naming, derived relational responding and equivalence relations, this study has merely scratched the surface of verbal behavior integration.

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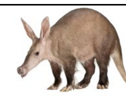
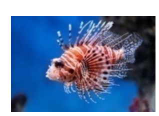
Table 1

Twelve 3-member vocal-written-picture classes in Study 2.

Class	Dictated Name (by experimenter **(A)**	Printed Word **(B)**	**Picture** (**C**)
1	"Aardvark"	Aardvark	
2	"Caribou"	Caribou	
3	"Fennec Fox"	Fennec	
4	"Humming Bird"	Humming	
5	"Ibis"	Ibis	
6	"Finch"	Finch	
7	"Koi"	Koi	
8	"Guppy"	Guppy	
9	"Lion Fish"	Lion fish	

10	“Skink”	Skink	
11	“Gecko”	Gecko	
12	“Chameleon”	Chameleon	

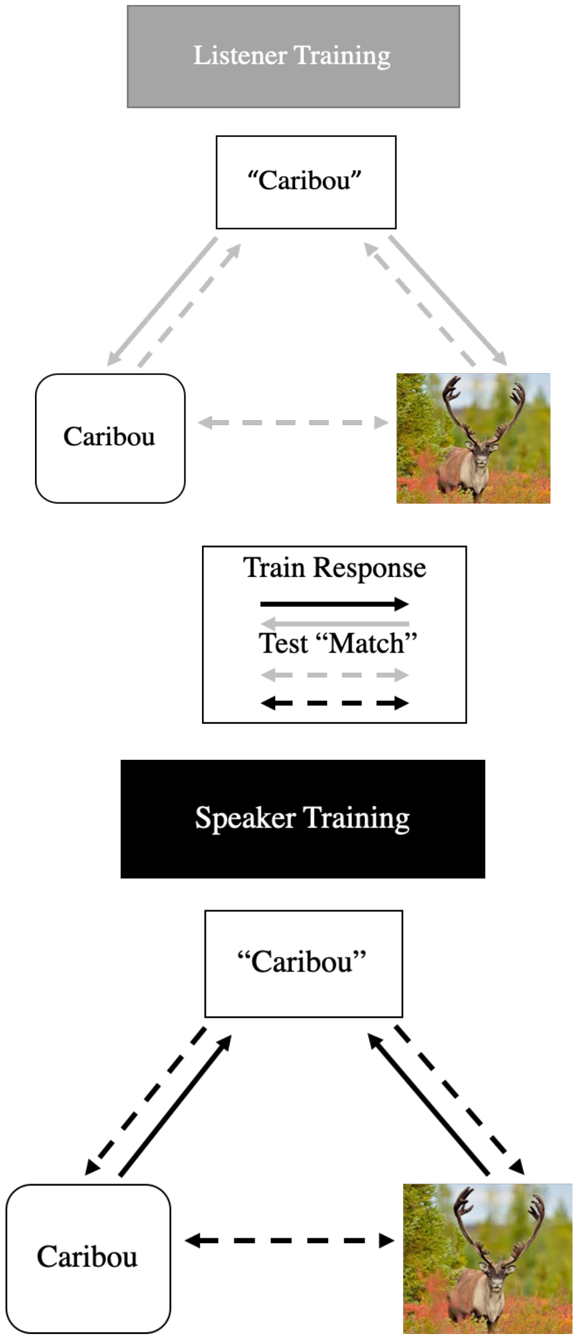


Figure 1: Sample of listener and speaker trainings during Study 2. Solid black/gray lines and the emergence of derived relation represented by the dashed black/gray lines.

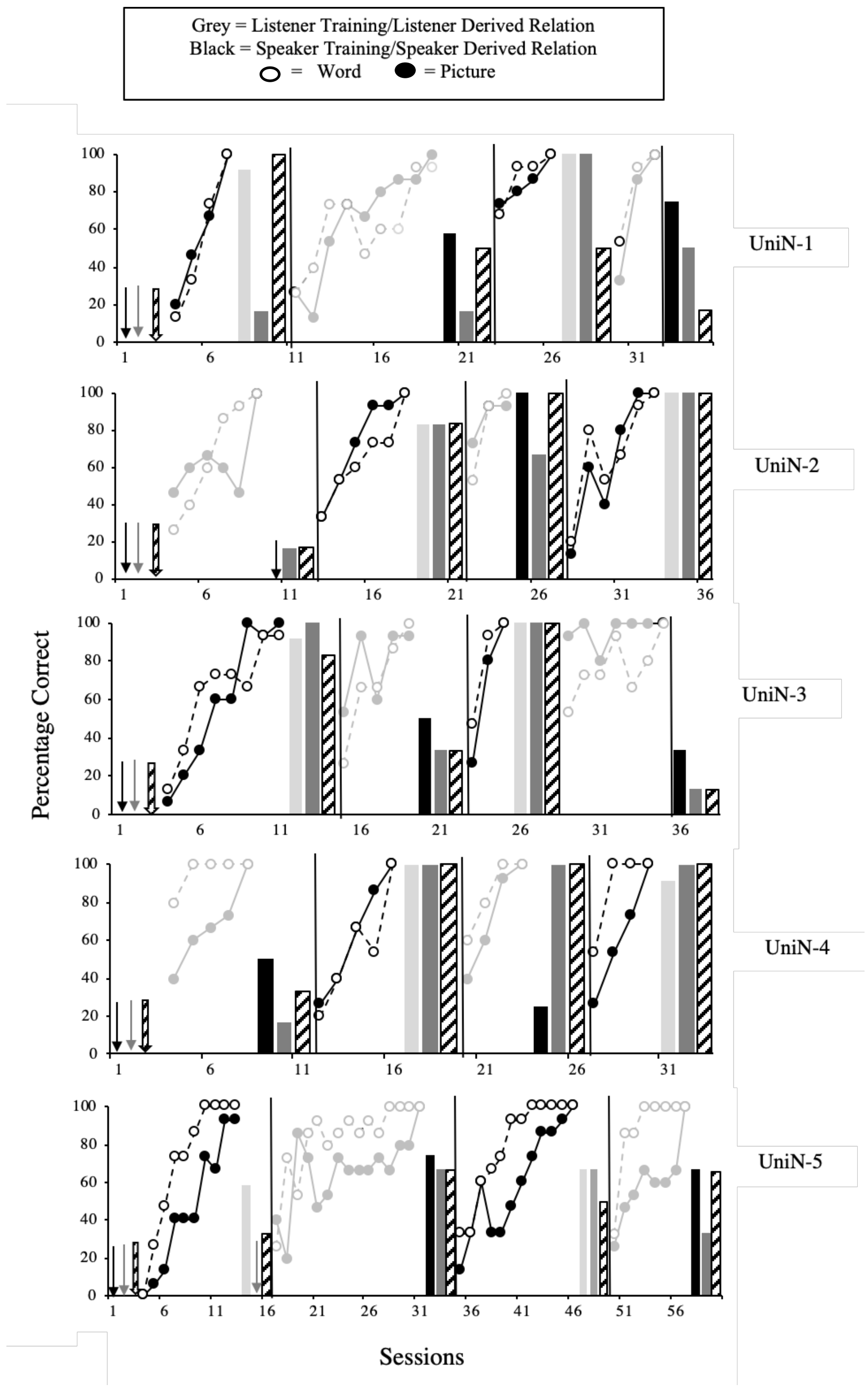


Figure 2. Acquisition of animal classes across 2 listener and 2 speaker phases, and scores for emergent relations after both Listener and speaker trainings across 5 UniN participants**.**

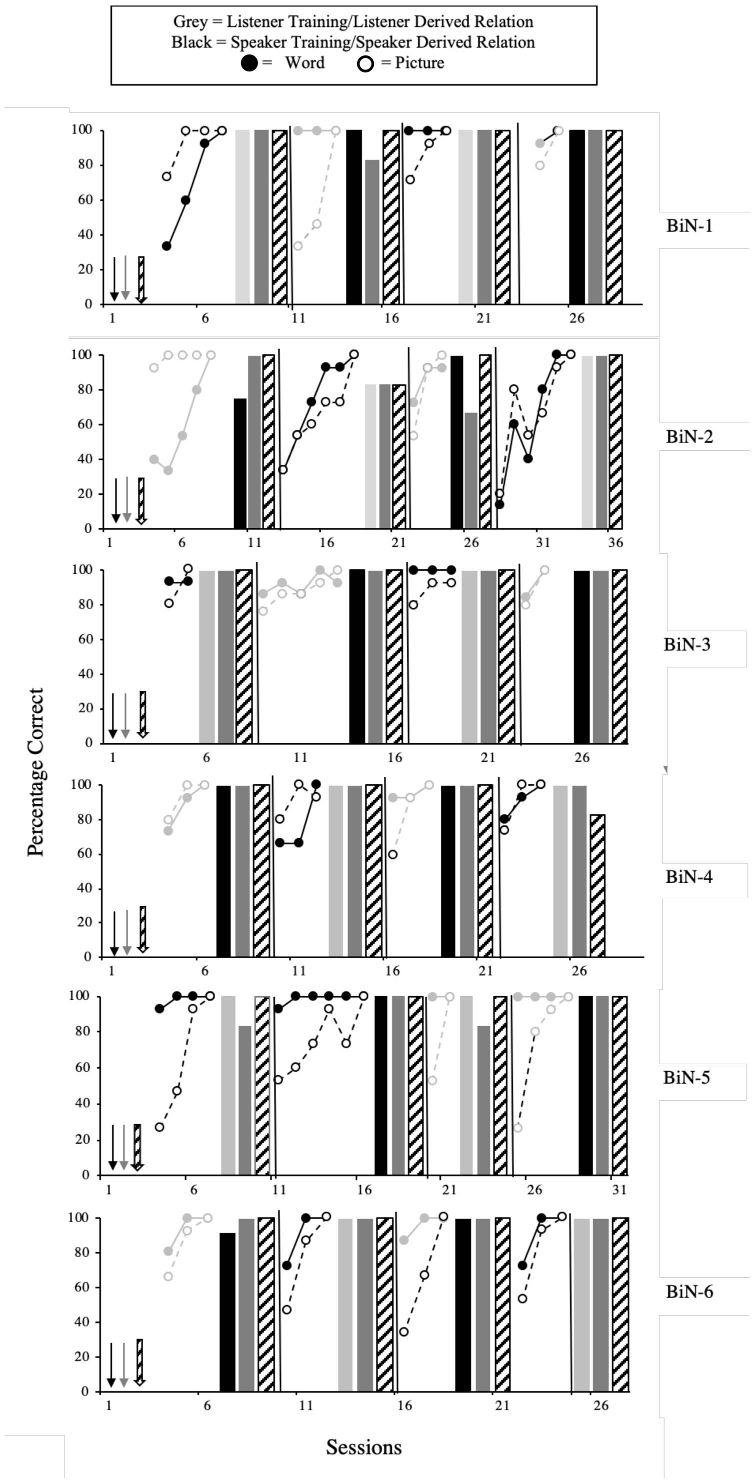


Figure 3: Acquisition of animal classes across 2 listener and 2 speaker phases, and scores for emergent relations after both Listener and speaker trainings across 6 BiN participants.

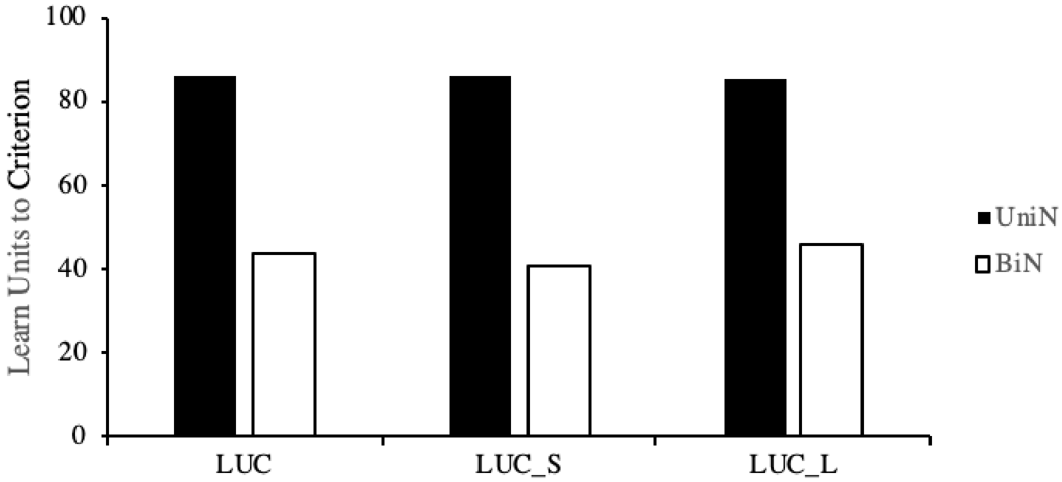


Figure 4. Learn units to criterion for the overall experiment (LUC), speaker (LUC-S), and listener (LUC_L), and) training protocols. Black bar represent UniN participants and white bars represent BiN participants.

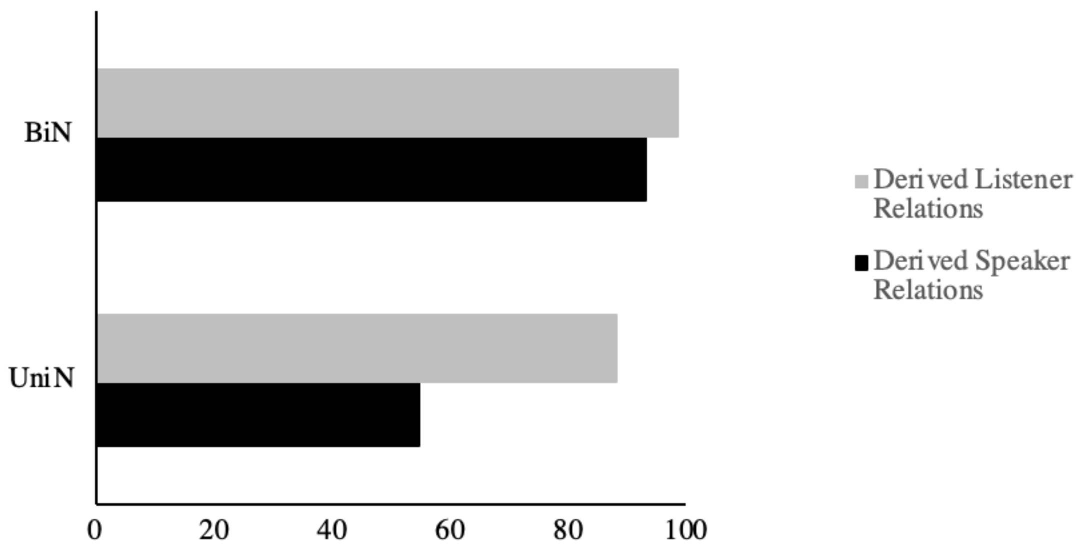


Figure 5. Percentage of derived relational responding for participants with various degrees of the Bidirectional Naming capability; BiN (n=6), and UniN (n= 5). Black bar represent UniN participants and white bars represent BiN participants.

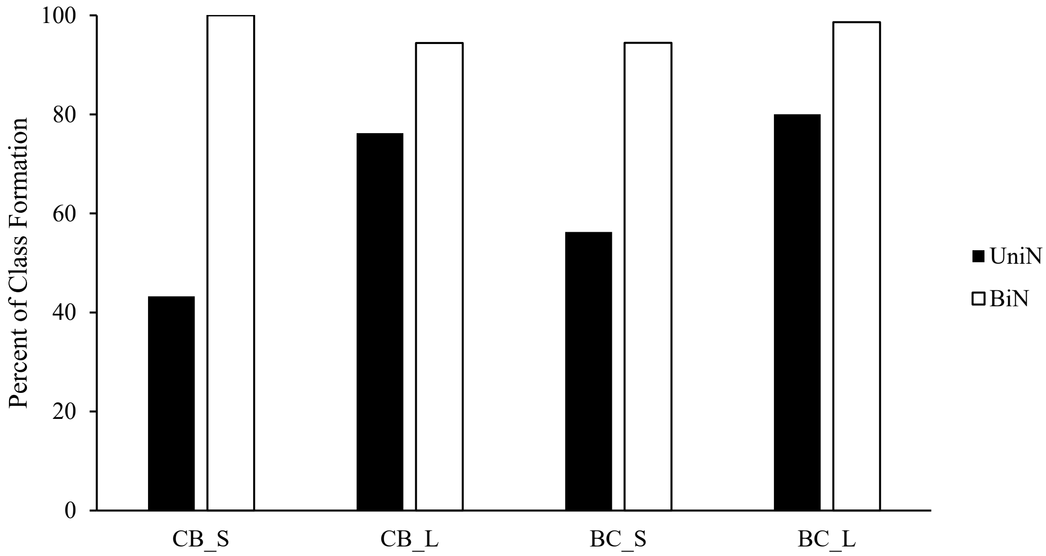


Figure 6. Percentage of CB and BC equivalence relations after each protocol training, for participants with various degrees of the Bidirectional Naming capability; BiN (n=6), and UniN (n= 5). Black bar represent UniN participants and white bars represent BiN participants.

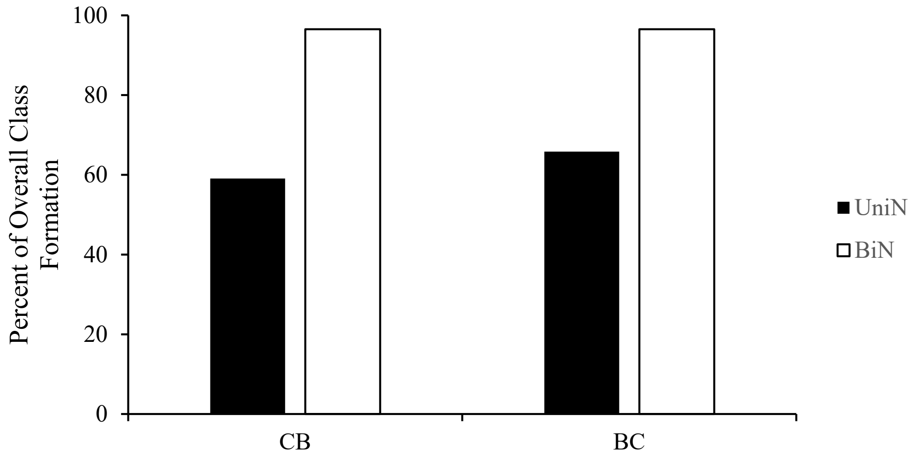


Figure 7. Percentage of CB and BC relations for participants with various degrees of the Bidirectional Naming capability; BiN (n=6), and UniN (n= 5). Black bar represent UniN participants and white bars represent BiN participants.

CHAPTER 4: General Discussion

Summary of Findings

Collectively, the results of Study 1 and Study 2 begin to fill in the gap and bridge various behavior analytic foci on language acquisition. These experiments dissected the intersections among the capability of bidirectional naming and derived relations to uncover their possible commonalities and differences. Specifically, participants with the BiN capability who learn incidentally from their environment through object-model name relations or antecedent presentations alone, derived both listener and speaker responses with high levels of accuracy. To put it more simply, during their object-name pairings as a listener (conditional discriminations-students engaged in point to responses) student indirectly learned as a speaker and vice versa. Participants with the UniN cusp that is a capability, or who learn listener but not speaker responses from antecedents, derived listener but not speaker responses. Particularly, when students were taught speaker responses using multiple object-name pairings (tact instruction – holding up card with no vocal antecedent student responds "caribou" etc.), the student learned listener responses indirectly. But when students were directly listener responses (i.e., listener training), students did not learn speaker responses incidentally from object-name pairings. During this training we directly reinforced a response that the student more than likely would have acquired without direct reinforcement. Since they can't incidentally learn speaker responses, they do not derive them. Participants who could not learn listener or speaker responses from antecedents (no incidental naming, or NiN) struggled to acquire listener and speaker responses and did not derive corresponding responses.

Study 1 Experiment 1 and Study 2 provided a snapshot of the general derived relations repertoires for each degree of bidirectional naming (i.e., NiN, UniN, and BiN). Across both analyses, we observed the same correlational pattern of responding to derived speaker and listener relations for children with UniN and BiN capabilities. In Study 1 Experiment 2, we provided evidence of causality between bidirectional naming and derived relations by establishing bidirectional naming and observing corresponding changes in those participants accuracy of deriving relation. Specifically, UniN participants' from Experiment 1 (Study 1) developed the stimulus control for BiN and then were able to derive speaker responses as they had been able to derive listener responses during Experiment 1(Study 1). These participants' performances at the end of Experiment 2 (Study 1) mimicked those of BiN participants in Experiment 1(Study 1), demonstrating that changes in BiN capabilities produced corresponding changes in derived relations.

Study 2 was designed to systematically replicate and clarify the findings of Study 1. During Study 2, participants responded in a similar manner as Study 1 across both listener and speaker responses. Both speaker and listener trainings were used to test emergent responding across UniN and BiN participants. Results indicate that speaker trainings were superior in producing derived relations and equivalence relations across both groups of participants. All UniN participants did not demonstrate the immediate emergence of equivalence classes or derived speaker relations following listener training. Whereas, 3 of the 5 UniN participants demonstrated the immediate emergence of equivalence classes after the completion of the speaker training.

What are Derived Relations?

The intersection of bidirectional naming and derived relations in this study begs a molecular analysis of what are derived relations. Researchers have suggested verbal repertoires mediate derived relations. Miguel (2018; 2016) has proposed common naming (e.g., assigning a respective name to stimuli in a class) and bidirectional naming (e.g., joining of speaker and listener repertoires) as mediating visual-visual and auditory-visual relations, respectively.

How does a child with UniN accurately derive listener responses but not speaker responses? Begin by considering that a child with the UniN capability is an individual who emits listener responses following the pairing of objects with names. Now, consider the structure of speaker training. During speaker training, an instructor holds up a picture of an object and allows the participant to emit the vocal tact. If the participant does not emit the correct tact, the instructor provides a correction that includes modeling the appropriate object-name relation. Thus, all speaker training learning opportunities involve the instructor or child pairing object-name relations. The direct reinforcement of speaker responses leads to the acquisition of those speaker responses and the repeated object-name pairings lead to emergent listener responses. This is contrasted with what occurs during listener trainings. The UniN capability is partially defined as *not being able to* learn speaker responses from object-name pairings. During listener training learning opportunities, an instructor places pictures of objects on the table, provides a tact, and allows the participant to emit a listener response to the correct comparison stimulus (i.e., a pointing response). If the participant does not emit the correct listener response, the instructor provides a correction that includes representing the object name and modeling the listener responses – or a model of the appropriate object-name relation. Thus, all listener training learning opportunities involve the instructor or child pairing object-name relations. The direct reinforcement of listener responses leads to the acquisition of those listener responses; however, the repeated object-name pairings do not lead to emergence speaker responses because object-name pairings do not result in emergent speaker responses for individuals with UniN – and this is demonstrated during the Naming Assessment. This molecular analysis suggests that bidirectional capabilities, or specifically, the degree of bidirectional capabilities account for the differential emergence of listener and speaker behavior during auditory-visual conditional discrimination training.

Speaker and listener trainings are implemented the same for children with NiN and BiN degrees of bidirectional naming, thus the differentiation in emergent behavior may also be explained by degrees of bidirectional naming. Children with NiN demonstrate during the Naming Assessment that they cannot emit listener or speaker responses following object-name pairings and this was confirmed during tests of derived speaker and listener responses. Children with BiN demonstrate during the Naming Assessment that they can emit both listener and speaker responses following object-name pairings. Thus, during speaker trainings, these participants learn speaker responses by instructors directly reinforcing speaker responses and the repeated object-name pairings give rise to listener responses during derived relations tests. The same logic applied to listener trainings. Participants with BiN learn listener responses by instructors directly reinforcing listener responses and the repeated object-name pairings give rise to speaker responses during derived relations tests. Collectively, across children with NiN, UniN, and BiN capabilities, responses that can be acquired from antecedent object-name pairings are emitted during derived relations tests and responses that cannot be acquired from these object-name pairings are not accurately emitted during derived relations tests.

The formation of equivalence relations during Study 2 are in line with Miguel's notion of common bidirectional naming, where dissimilar stimuli occasion the same speaker and listener behavior (Miguel, 2018). In Study 2, equivalence relations were visual-visual and accurate responding was defined as matching responses. Examining Figure 6 and 7 in Study 2, one notes that tests of equivalence relations were never higher than the most accurate derived listener or speaker responses. That is, accuracy during auditory-visual listener and speaker derived relations was either the same or higher than that of visual-visual equivalence relations. This suggests that accurate tacts of stimuli (e.g., common naming) were a prerequisite to accurate matching of visual-visual equivalence relations.

Integration of Theories

The capability of bidirectional naming is one of many theories that account for language acquisition, it allows an individual to observe a stimulus, hear its name and subsequently acquire the object-name relation (Horne & Lowe, 1996, Greer & Longano, 2010). Greer and Speckman (2009) incorporate this into their notion of Verbal Behavior Developmental Theory (VBDT) and develop a verbal behavior trajectory. This trajectory stemmed from multiple research studies that suggested certain instructional histories and sequence of experiences allow for the acquisition of operants, thus allowing them to be truly verbal (Greer & Speckman, 2009; Greer & Ross, 2008; Greer et al., 2017). Stimulus Equivalence (SE) (Sidman, 1994), Relational Frame Theory (RFT) (Hayes & Barnes- Holmes & Roche, 2002) and the Naming theory (Horne & Lowe, 1996) demonstrate various similarities across incidental language acquisition. All three theories are extensions of Skinner's (1957) theory of verbal behavior and seek to explain how language is learn incidentally; they all demonstrate some form of bidirectional capability (bidirectional naming, symmetry, mutual entailment) and employ multiple exemplar instruction to test for and induce these indispensable phenomena. The study of derived relations has been a growing field that has produced a fruitful body of research and application, that correlate with the aforementioned theories (Miguel & Petursdottir, 2011). In regard to relations aside from equivalence, RFT explain that one can derive numerous relations of correspondence, distinction, comparison, opposition, experiences, beliefs etc. These relations are explained in terms of frames and attribute to how one learns word-meaning relations (Hayes et al. 2002). Furthermore, these relational frames demonstrate contextually controlled and arbitrarily applicable properties, and with exposure to MEI and operant conditioning can become generalized operants (Healy, Barnes-Holmes, & Smeet, 2000). These relational frames result in the production of derived relational responding; which allow a student to become truly verbal.

The results follow previous literature and add empirical evidence that join the verbal behavior foci and derived relations literature to clarify which children, with which verbal cusps, benefit from instruction that incorporates derived relations. Greer and colleagues propose the Verbal Behavior Developmental Theory (VBDT) stating that students follow a verbal behavior development trajectory; highlighting that students who acquire listener responses before developing speaker responses (Greer & Ross, 2008; Greer & Speckman, 2009). This theory accounts for instructional changes, such as the addition of Instruction Demonstration Learn Units (IDLUs) that affect the way a student can be taught (Greer, Corwin, & Buttigieg, 2011). Whereas, other theories like SE and RFT focus on what we can afford and shape curriculum based on specific relations (Critchfield & Twyman, 2014). Bridging together these theories provide a route that allow for a thorough understanding of the developmental trajectory and curricula that are engineered for emergence.

Implications for Teaching and Emergent Behavior

Empirical evidence based on the current study suggest that bidirectional naming gives rise derived relations. Once a student acquires the capability of BiN, strategic scientist can start designing curriculum that incorporates derived relations. They can also start by changing the type of instruction delivered such as Instruction Demonstrations Learn Units (IDLUs), which accelerates the student's rate of acquisition (Greer, et al., 2011).

Other studies, such as Contreras, Cooper and Kahng (2019) provide a review for the efficiency of listener and speaker instruction. This among other studies, suggest a generic recommendation that we should teach speaker and test for the emergence of listener responses (Petursdottir & Carr, 2011). The current findings suggest that bidirectional naming and derived relations synonymous, thus one is a proxy for the other. In utilizing one training type independent of a students' capability, we overlook the student's ability to derive speaker responses from when completing listener trainings. Following this recommendation, if one always teaches speaker responses and tests for emergent listener responses, all you can determine is if the student has unidirectional naming, which has limited implications for teaching tactics and curriculum design. However, interspersing teaching listener responses and tests for emergent speaker responses will allow an instructor to determine if the student has bidirectional naming, which does have implications for teaching tactics (e.g., IDLUs, Greer et al., 2011) and curriculum design (e.g., incorporating derived relations, Stromer, Mackay, & Lawrence, 1992). The current study challenges the suggestions of literature reviews and adds clarity to the research outcomes available in the literature.

The outcomes of this study have both conceptual and practical implications. Conceptually, Hawkins et al. (2018) proposed a classification framework on naming, suggesting that naming can be dissected into common bidirectional naming and intraverbal bidirectional naming. Although this framework is imperative to making cohesive contributions to verbal behavior research, it is limited in its scope. The current research demonstrated that these broad categories are not necessarily functional - a student with UniN direct reinforcement can also have UniN for antecedents. That is, the strong correlation between learning from antecedents (BiN) and deriving corresponding behavior following direct reinforcement found in this study suggest that these two repertoires are very similar and likely interrelated. However, continued research will help to identify whether subtypes of bidirectional naming are warranted.

The primary focus in the current study was to evaluate derived relational responding across training conditions, in each participant. This analysis will assist in how instruction should be differentiated across verbal developmental capabilities. Once a teacher is able to differentiate instruction based on a student's pivotal skills, they are able to produce efficient learning in the classroom.

Limitations

There were several limitations throughout Study 1 and Study 2. First, across all the experiments, a larger sample size would have been preferable. An equal number of participants should be selected per degree of BiN (e.g., 10 BiN, 10 UniN, and 10 NiN). Future studies should increase this same size, especially data from NiN and BiN participants. Collecting more data would affirm the correlation between derived relations and the degree of bidirectional naming. This would allow for more group statistical analysis to be conducted. Second, researchers should also obtain more IOA and fidelity. Third, post assessments were not conducted at the completion of each study, which can affect the conclusion of maintenance of training. Last, in the current studies participants were tested for BiN once (i.e., at the onset of the study) then categorized, future studies should conduct a minimum of two naming experiences across both familiar and unfamiliar stimuli, this will assist in generalization of results.

Future Research

This series of experiments were designed to clarify previous literature and answer the fundamental question of program sequencing (Contreas, Cooper, & Kahng, 2019). These data support research which has suggested that the student's verbal repertoires do interact with the establishment of derived relational responses (Miguel & Kobari-Wright, 2013; Morgan, 2018; Miguel & Petursdottir, 2008). Thus, the capacity of derived relations expands as verbal capabilities expand. Future studies should extend these trainings to group instruction. It is important to identify if similar findings could be found in a group setting. Applying these trainings in a group setting adds to the efficiency of instructions especially in inclusion settings. Other capabilities such as observational learning and generalized motor imitation should be evaluated. Hawkins et al. (2018) proposed a conceptual framework on bidirectional naming, future studies should dissect the categories of BiN and evaluate how derived relations map onto the various subtypes of naming.

The next stage of research should evaluate different curricula. This speaks directly to engineering for emergence across various educational content (i.e., reading, math, and science). Curricula should be designed with the students' level of verbal behavior in mind, this promotes the efficiency and effectiveness of instruction. For example, if a student has BiN it is not warranted to teach them all the relations directly, rather we should determine what training method would be the most efficient because the data in the current study suggest that they will derive relations.

These findings are merely scratching the surface of integration. As a field, it is imperative that we view each focus in light of their similarities. Understanding each phenomenon helps us to integrate the different approaches and their respective findings. This implies these findings should not be limited to one behavioral camp or journal. Verbal behavior research, that focus on the development of tactics to establish developmental milestones, should collaborate with SE and RFT, and vice versa. Therefore, with these contributions, have a shared mission of understanding the complexities of verbal behavior and how it impacts emergent learning.

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