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**Assessing and Training Early Emergent Derived Relational
Responding in Children with Autism**

Siri Ming

Dissertation submitted in partial fulfilment of the requirements for the
Degree of Doctor of Philosophy in Applied Behaviour Analysis

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September, 2015

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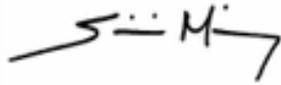
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Declaration Regarding the Work

I, the **Candidate**, certify that the Thesis is all my own work and that I have not obtained a degree in this University or elsewhere on the basis of any of this work.

This thesis is the result of my own investigations, except where otherwise stated. The following chapters include work conducted in collaboration with other students:

- Chapter 3 includes work that was written in collaboration with Laura Moran, Ph.D. (Thesis titled *Testing and Developing a Protocol for Training and Assessment of Relational Precursors and Abilities* submitted August 2013)
- Chapter 9, Study 9.2, was conducted in collaboration with Teresa Mulhern, ABA Ph.D. candidate.

A handwritten signature in black ink, appearing to read 'S. M.' with a stylized flourish at the end.

Sept 25, 2015

Signed: ----- Date: -----

Abstract

Many children with autism fail to develop generative language despite intensive teaching; their language can be described as “rote”. Research in the area of derived stimulus relations, in particular Relational Frame Theory (RFT), suggests that derived relational responding (DRR) is the key process involved in generative language and that training children to be able to do DRR might remediate deficits in generative verbal behavior. However, there has been little research done with individuals with very limited or no pre-existing repertoires of DRR. This thesis thus focused on the assessment and training of three early emergent patterns of relational responding in such populations: coordination (sameness), distinction, and class inclusion. It was decided to focus on relations that included both auditory and visual stimuli since these are likely particularly important in the development of conversation and early language. In accordance with RFT, deficits were addressed using multiple exemplar training (MET).

The first line of research (Chapters 5 and 6) involved assessing and training derived coordination with individuals with very early language repertoires. The effect of instructional context on DRR was examined across several studies, including one which used a reversal design, and provided the first ever demonstration of a reversal effect with respect to the emergence of DRR. This line of research thus identified instructional context as an important consideration for assessment and training, particularly when working with individuals who have limited repertoires of DRR. MET in the context of a game about familiar animals and their names and sounds was then used to establish combinatorially entailed intraverbal responding with two individuals with autism who were not previously able to demonstrate combinatorial entailment even within this very familiar context. Notably, this was the first such demonstration with individuals with limited language skills. Apart from coordination, another pattern of early emergent relational responding is distinction. Hence, in the current thesis, same/difference relations were the next focus. Chapter 7 presented a cross-disciplinary literature review of the same/different literature, while Chapter 8 presented empirical research featuring both

same and different relations as well as their derived combination. In this research, MET (in the context of a game about animals and the food they like) was used to establish DRR; these skills further generalized to a simple test of reading comprehension. Distinction has been the subject of very little previous applied work, and the research in this thesis is the first to establish a new repertoire of DRR in a frame of distinction as well as demonstrate generalization of the skill to an academically-relevant context. The third line of research (Chapter 9) provided the first demonstration of the effectiveness of MET in establishing generalized class inclusion, an important nonarbitrary foundation for advanced ‘hierarchical’ DRR relevant to categorization.

Findings provided further support for the contention made by RFT that DRR is a learned operant, and provided important evidence of the effectiveness of MET in establishing repertoires of DRR with individuals who have limited language skills. In addition to the theoretical implications of the work, there were also significant practical implications. In all three lines of research, new methods for assessing and training early repertoires of DRR were developed that can easily be implemented by practitioners in the course of typical early intervention programs, either in tabletop formats or in an easily managed iPad app. The technology of derived stimulus relations research must be able to be disseminated to practitioners if it is to have the socially significant impact many researchers hope for, and the studies and reviews that form this thesis have provided another step towards that goal.

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All my experiment.com backers—knowing you are all out there believing in my work enough to provide tangible support meant even more to me than the money. Special thanks to Julia Fiebig, Eric Fox/Foxylearning, Catherine Green, Michelle

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Publications and Conference Presentations

Publications

**indicates publications arising directly from this thesis*

- *Ming, S. & Stewart, I. (in preparation). A review of research into difference relations. *Journal of Applied Behavior Analysis*.
- *Ming, S., Stewart, I., McElwee, J., & Bynum, K. (2015). Contextual control over derived relational responding in a teenager with autism. *Research in Autism Spectrum Disorders*, 19, 7-17. doi:10.1016/j.rasd.2015.03.003
- *Ming, S., Moran, L., & Stewart, I. (2014). Derived relational responding and generative language: Applications and future directions for teaching individuals with autism spectrum disorders. *European Journal of Behavior Analysis*, 15(2), 199-224. doi: 10.1080/15021149.2014.11434722.
- Moran, L., Stewart, I., McElwee, J., & Ming, S. (2010). Brief report: The training and assessment of relational precursors and abilities (TARPA): A preliminary analysis. *Journal of Autism and Developmental Disorders*, 40(9), 1149-53. doi:10.1007/s10803-010-0968-0
- Moran, L., Stewart, I., McElwee, J., & Ming, S. (2014). Relational ability and language performance in children with autism spectrum disorders and typically developing children: A further test of the TARPA protocol. *The Psychological Record*, 64(2), 233-251. doi:10.1007/s40732-014-0032-0
- Moran, L., Walsh, L., Stewart, I., McElwee, J., & Ming, S. (2015). Correlating derived relational responding with linguistic and cognitive ability in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, 19, 32-43. doi:10.1016/j.rasd.2014.12.015
- *Stewart, I., McElwee, J., & Ming, S. (2013) Language generativity, response generalization and derived relational responding. *The Analysis of Verbal Behavior*, 29(1), 137-155 Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3659503/>.

Manuscripts in Preparation

- Ming, S., & Stewart, I. (in preparation). Teaching the meaning of "different": Establishing derived relational responding in patterns of coordination and distinction
- Ming, S., Mulhern, T., Stewart, I., & Moran, L. (in preparation). Testing and Training Class Inclusion in Typically Developing Young Children and Individuals with Autism.

Conference Presentations and Posters

- Ming, S., Moran, L., Stewart, I., McElwee, J., & Bynum, K. (2015). *Assessing Derived Relational Responding Skills with Children with Autism*. Research symposium paper presented at the Association for Professional Behavior Analysts Conference, Seattle, WA.
- Ming, S., Mulhern, T., Moran, L., & Stewart, I. (2015). *Training Class Inclusion with Typically Developing Children and Children with Autism*. Research symposium paper presented at the Association for Professional Behavior Analysts Conference, Seattle, WA.
- Ming, S. & McElwee, J. (2013) *Generative Teaching Protocols*. Workshop presented at the Autism New Jersey Conference, Atlantic City, NJ.
- Ming, S., Stewart, I. & McElwee, J. (2013) *Assessing and Training Derived Relational Responding Abilities: The impact of context and other assessment factors*. Poster presented at the Association for Professional Behavior Analysts Conference, Las Vegas, NV.
- Moran, L., Stewart, I., Ming, S. & McElwee, J. (2013) *Testing a computer-based training protocol for the assessment of generative verbal behavior in children with ASD*. Poster presented at the Association for Professional Behavior Analysts Conference, Las Vegas, NV.
- McElwee, J. & Ming, S. (2012). *Generative teaching protocols for learners with ASD and other Developmental Delays*. Workshop presented at the 2012 Pennsylvania State National Autism Conference.
- Ming, S. & Stewart, I. (2012) *Teaching for Generativity: Training derived relational responding abilities with children with autism*. Symposium paper presented at the 2012 annual conference of the Association for Contextual Behavioral Science, Washington, DC.
- Ming, S., McElwee, J., & Stewart, I. (2012). *Practical Applications of RFT to EIBI Programs*. Workshop presented at the 2010 and 2011 annual conferences of the California Association for Behavior Analysis; the 2010, 2011, and 2012 annual conferences of the Association for Behavior Analysis: International; and the 2011 Pennsylvania State National Autism Conference.
- Ming, S. & Stewart, I. (2012) *Assessing and Training Derived Relational Responding Skills: A demonstration of contextual control in equivalence*. Symposium paper presented at the annual conference of the Association for Behavior Analysis: International, Seattle, WA.
- Ming, S., Stewart, I., Moran, L. & McElwee, J. (2011) *Testing a computer-based training protocol for the assessment of generative verbal behavior in children with ASD*. Poster presented at the Association for Behavior Analysis Autism Conference, Washington, DC.

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Chapter 1:

Overview

Overview

A focus on teaching language is one of the critical components of any effective intervention program for children with autism (e.g., National Research Council, 2001). Decades of research have established the effectiveness of applied behavior analysis as an intervention for autism, and outcome research has shown that many individuals who receive early intensive behavioral intervention may progress to the point of their skills being nearly indistinguishable from their peers in terms of their language abilities (e.g., Butter, Mulick, & Metz, 2006; Lovaas, 1987; McEachin, Smith & Lovaas, 1993; Perry, Cohen, & DeCarlo, 1994). However, even with intensive behavioral intervention, many children continue to require intensive direct teaching to learn new vocabulary and concepts. These children may have large vocabularies, but they don't use the words they know fluently, flexibly and spontaneously—their language is "rote", and they have difficulty responding when something is new in the way an instruction is phrased, or if the context is different.

This is a critical and perplexing problem for teachers and behavior analysts—how do we teach children to engage in the ever changing flow of conversations, requiring speaking in ways they haven't been specifically taught, and understanding sentences they've never heard before? It is arguable that up until recently, behavior analysis has lacked a conceptually systematic framework for addressing the extent of generativity involved in such interactions. However, an increasing quantity of empirical evidence (see e.g., Dymond & Roche, 2013) now suggests that the phenomenon of derived relational responding (DRR) may be a key part of the answer to understanding and influencing behavior in this domain and it was this contention that led to the exploration of early emergent derived relational responding that forms the core work of this thesis. This exploration has included a broad examination of the literature relevant to the emergence and facilitation of early relational responding repertoires, as well as the development and testing of new assessment and teaching procedures with a focus on establishing repertoires related to derived relational responding when they are not yet present. As such, it is envisaged that this work will further the existing research on early emergent

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repertoires of DRR, as well as facilitating a broader effort to develop a comprehensive early intervention curriculum that focuses on teaching skills that have the potential to lead to more generative language for children with autism.

Before presenting the studies forming the current line of research, first the relevant background theory and research will be discussed. In Chapter 2, the main behavior analytic approaches to teaching language to children with autism in the context of early intensive behavioral intervention (EIBI) programs will be described. Historically, such programs have followed either relatively traditional linguistic approaches to language and used the procedures developed by Lovaas (1987), or they have used Skinner's (1957) analysis of verbal behavior as an approach to curriculum development and teaching procedures. The differences between these two approaches will be considered, along with a description of Skinner's (1957) analysis. Importantly in the present context, neither of these approaches has focused on the development of generative language. In many cases, examples of generative language have been described as "response generalization." The use of this term will also be discussed, and the argument made that derived relational responding accounts provide a better framework for understanding generativity.

In the third chapter, the theoretical background to DRR accounts of language will be discussed, including a description of derived equivalence as well as an explanation of the main tenets of Relational Frame Theory (RFT; Hayes, Barnes-Holmes & Roche, 2001) which argues that stimulus equivalence is only one of many diverse learned patterns of DRR (referred to as relational frames) and that DRR in its many diverse patterns both constitutes the core of human language and cognition and can be trained. A review of the applied literature on DRR with individuals with developmental disabilities will be presented, along with suggested directions for future research. An overview will then be provided of the recommendations that have shaped the current line of research, which explores the assessment and multiple exemplar training (MET) of DRR skills across several relational patterns of responding (relational frames): coordination, distinction, and hierarchy.

Following the presentation of general theoretical background to DRR in the opening chapters, Chapter 4 present the background to the two sets of studies that

follow, which explored the frame of sameness or “coordination”, which is the first pattern of DRR to develop in typical language acquisition. In this chapter the protocol used in the current research, the Training and Assessment of Relational Precursors and Abilities (TARPA; Moran, Stewart, McElwee & Ming, 2010, 2014; Moran, Walsh, Stewart, McElwee & Ming, 2015), will be described. Additionally, factors that can affect the demonstration of DRR will be discussed, and a rationale will be provided for the structure and context of the assessment and training tasks used.

Following this background information, the first series of studies will be presented (Chapters 5 and 6). These focused on the frame of coordination in terms of variables to consider when assessing very early derived relational responding repertoires as well as MET for establishing such skills. These studies specifically examined a pattern of derived tact/listener/intraverbal responding, using both visual and auditory stimuli in baseline and mutually entailed derived relations, and auditory stimuli in the combinatorially entailed derived relations. These studies include a reversal effect with respect to DRR based on contextual variables alone (Ming, Stewart, McElwee & Bynum, 2015), thus highlighting a very important consideration for assessing and training when working with individuals with very limited repertoires of DRR. These studies also include the first demonstration of the effectiveness of MET for establishing combinatorially entailed intraverbals using vocal/auditory stimuli, providing both theoretical support for the contention made by RFT that DRR is a learned operant as well as an important practical tool for interventionists working with children at early language levels.

The next series of studies examined the use of MET for establishing DRR in combined frames of coordination and distinction, the latter being another probably relatively early emergent pattern of DRR in typical development. First, the literature on responding in accordance with same/different relations will be presented (Chapter 7), including research on both non-arbitrary and arbitrary relational responding across a number of disciplines. There has been very little applied research on distinction, and thus directions for future research will be presented, along with the recommendations that have shaped the current research. Chapter 8 will then present

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a series of studies that involved assessing and training transformation of function through derived same/different relations. This work is the first demonstration of the effectiveness of MET for establishing transformation of function in accordance with same/different relations with children with autism who do not already have this repertoire. The core protocol involved a game-like context that is relevant to conversational skills and that facilitated successful generalization of the DRR skills to an academically-relevant task, using a simple test of reading comprehension.

The final series of studies will be presented in Chapter 9. These examined the use of MET for establishing class inclusion, an important non-arbitrary relational repertoire underlying hierarchical relational responding and advanced categorization, which itself relies on frames of coordination and distinction. This series of studies used tabletop procedures and a combination of auditory/vocal and visual stimuli, and represents the first demonstration of a successful training procedure to establish a class inclusion repertoire with children with autism, as well as a demonstration of generalization and maintenance of that repertoire both with children with autism as well as typically developing preschoolers.

The thesis concludes with a final chapter discussing the current line of research and future directions based on these results as well as the broader reviews of the literature which form the background for the current research. The results of all three lines of research provided further support for the contention made by RFT that DRR is a learned operant, and provided important evidence of the effectiveness of MET in establishing repertoires of DRR with individuals who have limited language skills. In addition to the theoretical implications of the work, there were also significant practical implications. In all three lines of research, new methods for assessing and training early repertoires of DRR were developed that can easily be implemented by practitioners in the course of typical early intervention programs, either in tabletop formats or in an easily managed iPad app. The technology of derived stimulus relations research must be able to be disseminated to practitioners if it is to have the socially significant impact many researchers hope for, and the studies and reviews that form this thesis have provided another step towards that goal.

Chapter 2:
Behavior Analytic Approaches to Teaching Language to Children
with Autism

Portions of this chapter have been previously published in:

Stewart, I., McElwee, J., & Ming, S. (2013). Language generativity, response generalization, and derived relational responding. *The Analysis of Verbal Behavior*, 29(1), 137-55.

Teaching Language

Autism spectrum disorder (ASD) is characterized by impairments and delays in communication and social skills, and by repetitive behavior (American Psychiatric Association, 2013). Applied behavior analysis has a long-standing tradition of addressing such skills and deficits with individuals with developmental delays (e.g., Hart & Risley, 1968; Risley, 1968; Schreibman 1978; Schumaker & Sherman, 1970; Wheeler & Sulzer, 1970; Wolf, Risley & Mees, 1964), and has been recognized for nearly two decades as a foundation for successful, empirically based interventions for children with autism (California Departments of Education and Developmental Disabilities, 1997; New York State Department of Health, 1999; Maine Administrators of Services for Children with Disabilities, 2000; National Research Council, 2001; National Autism Center, 2009). Interest in early intensive behavior analytic intervention (EIBI) programs for children with autism was spurred by Lovaas's (1987) seminal outcome study reporting that 47% of children in the EIBI program attained normal-range functioning as measured by both educational achievement and standardized test scores. Lovaas's program (see Smith, 2003, for an overview) was characterized not only by intensity of service (averaging 40 hours per week during the first two years of treatment) but by a comprehensive, manualized set of treatment procedures firmly grounded in operant theory, with careful attention paid to systematic teaching and generalization. Discrimination training procedures (*discrete trial training*), and the use of reinforcement of appropriate behavior combined with extinction and punishment procedures, were used to address self-stimulatory and aggressive behaviors while teaching compliance, receptive and expressive language, along with a host of other goals relevant to each child's skills and deficits. These results have been replicated and extended by a number of programs, resulting in many children with autism progressing to the point of age-typical language and academic skills following EIBI (e.g., Butter, Mulick, & Metz, 2006; Perry, Cohen, & DeCarlo, 1994; McEachin, Smith & Lovaas, 1993).

Approaches to Teaching Language in EIBI programs

Behavior analytic intervention programs have evolved over the decades since Lovaas's (1987) study, to incorporate the broad and growing base of research on effective teaching methods and functional behavior analytic intervention strategies, and now encompass a wide variety of commercially available curricula and teaching models. A focus on teaching language skills has been identified as one of the critical components of effective intervention programs for children with ASD (e.g., National Research Council, 2001), and behavior analytic approaches to the treatment of ASD typically place an emphasis on the analysis and development of such skills (e.g., see Sundberg & Michael, 2001). The curricula and theoretical basis used for teaching language within EIBI programs can nonetheless be broadly divided into a) programs following a more traditional linguistic approach to language as used by programs that have grown out of the Lovaas model (e.g. Center for Autism and Related Disorders, 2013; Leaf & McEachin, 1999; Lovaas, 2003; New England Center for Children, 2015; Maurice, Green & Luce, 1996), with more emphasis on structured intensive discrete trial teaching, and b) those which follow a Skinnerian analysis of verbal behavior (e.g., Barbera, 2007; Greer & Ross, 2008; Partington, 2006; Sundberg, 2008), with an attendant focus on using Skinner's (1957) classification of verbal operants along with a heavy emphasis on an analysis of motivating operations during teaching (e.g., Carbone, 2013) and an emphasis on the use of natural environment training (Sundberg & Partington, 1999).

Lovaas Programs

The language teaching model in Lovaas programs is based on a traditional linguistic analysis in terms of expressive and receptive language skills. Contemporary programs include mand training in their curricula (e.g., Center for Autism and Related Disorders, 2013), but in general these programs continue to focus first on establishing learner readiness, matching, imitation, instruction following, and receptive discrimination before working on any "expressive" language (see Smith, 2003, for an overview). The language aspects of these curricula

are generally descriptive in nature (e.g., identifying common nouns; identifying community helpers; answering “wh” questions; Leaf & McEachin, 1999).

Lovaas programs obviously have a strong evidence base in terms of outcome studies (see Reichow, 2012 for an overview). For example, with similar results to Lovaas’s (1987) study, Sallows and Graupner (2005) found that 48% of their participants in both parent-directed and clinic-based EIBI (using the same procedures in each setting) achieved normal range IQs along with improvements in adaptive functioning, measures of language skills, and autism severity. Nonetheless, these programs have been criticized from within behavior analysis for their neglect of a functional approach to language (Sundberg & Michael, 2001).

Verbal Behavior Programs

The analysis of verbal behavior. Skinner’s (1957) analysis of verbal behavior was a landmark theoretical work. It was the first treatment of language as operant behavior, described in the same terms as all other operant behavior: learned through a history of reinforcement, and influenced by environmental variables. Skinner specifically defined verbal behavior as responses for which reinforcement is mediated by a member of the verbal community (p 1-2), as distinguished from nonverbal behavior; notably, this definition does not rest on any particular topography of response. “Verbal operants” were defined with respect to their functional antecedent controlling variables and characteristic consequences, rather than by their topography or meaning, thus paving the way for studying language acquisition from a radical behavior analytic perspective. While it was heavily criticized at the time by linguists (e.g., Chomsky, 1959), and has in the years since been critiqued within the field of behavior analysis (e.g. Hayes, Blackledge & Barnes-Holmes, 2001; Hayes & Barnes-Holmes, 2004; Leigland, 1997), *Verbal Behavior* has been the foundation for significant clinical work and applied research, albeit primarily (though not exclusively) with individuals with developmental disabilities (see, e.g., Sautter & LeBlanc, 2006; Sundberg, 1998; Sundberg & Michael, 2001; Dixon, Small & Rosales, 2007).

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In *Verbal Behavior*, Skinner identifies a number of “primary” verbal operants as well as secondary verbal operants (i.e., “autoclitics”). It is these verbal operants which form the foundation of the analysis used by programs for children with autism that are often termed the “verbal behavior approach” (e.g., Barbera, 2007). Skinner’s conceptualization of the importance of motivational variables (i.e. satiation and deprivation) has also spurred additional theoretical and empirical work on motivation, particularly the conceptualization of motivating operations (Michael, 1988, 2000). As previously noted, the emphasis on motivational variables in the Skinnerian analysis of verbal behavior is also a primary distinguishing feature of verbal behavior programs.

Motivational variables are of particular importance for the verbal operant Skinner termed the *mand*. A mand is a response which is under the antecedent control of motivating operations (MO), for which the characteristic consequence is that stimulus which has been established as reinforcing by the MO (Michael, 1988). The mand is unique as a verbal operant in this respect, in that all other verbal operants function to access generalized conditioned reinforcers. Within verbal behavior programs, it is emphasized as the first skill to teach, since it by definition provides access to powerful reinforcement (Sundberg, 2010). Given such an emphasis, it should not be surprising that the vast majority of empirical work from a Skinnerian verbal behavior perspective has focused on the mand (Sautter & LeBlanc, 2006; Dixon, Small & Rosales, 2007). Applied research on manding has included studies of procedures for teaching initial vocal mands to young children with autism (Ross & Greer, 2003), methods for manipulating conditioned motivating operations for teaching signed mands to deaf adults with developmental delays (Hall & Sundberg, 1987), and the development of functional communication training procedures (e.g., Carr & Durand, 1985).

In contrast to the mand, the *tact* is defined as a response “evoked by a particular object or event or property of an object or event” (Skinner, 1957, p. 82)—that is, the tact is evoked by a discriminative stimulus rather than a motivating operation. Research on tacting has included the development of transfer of stimulus control procedures for effectively teaching tacts (e.g., Sundberg, Endicott &

Eigenheer, 2000), methods for increasing the variability of tacts (e.g., Heldt & Schlinger, 2012), and the appropriate sequence of teaching tacts and listener responses (see Petursdottir & Carr, 2011).

The *echoic* is a verbal response (as defined by Skinner) which is evoked by a verbal stimulus with which it has point-to-point correspondence and formal similarity: that is, the discriminative stimulus and response share the same topography (Skinner p 55). The conceptualization of the echoic importantly does not specifically require a *vocal* response; like all verbal operants, the topography of the response is irrelevant to its definition. Thus, imitating an ASL sign could also be defined as echoic. Vargas (1982) has suggested that a better term for this type of operant would be the more generic “duplic”, thus more clearly encompassing other nonvocal response forms such as sign language or writing/typing. There has been comparatively little research on establishing echoic behavior, primarily focusing on procedures for establishing vocal stimuli as reinforcers and thus facilitating echoic behavior through automatic reinforcement (e.g., Sundberg, Michael, Partington, & Sundberg, 1996). Other research utilizing echoic responding has focused on the use of echoic behavior in stimulus control procedures for establishing other verbal operants (e.g., Kodak, Fuchtman & Paden, 2012).

Like echoics, *intraverbals* involve a verbal response to a verbal stimulus; however, in this case the response does not have point-to-point correspondence with the discriminative stimulus (Skinner, 1957, p 71). Intraverbals thus encompass a very wide range of language responses, from simple fill-in-the-blank responses (e.g., “twinkle, twinkle, little...” “star”) and answering simple “wh” questions (such as “what is your name?”), to advanced conversational skills and answering very complex questions (such as in tests of reading comprehension); most higher level academic responding would be considered intraverbal (Sundberg & Sundberg, 2011). Clearly an intraverbal repertoire is critical to language development—Greer and Ross (2008) note that “by engaging children in more complex intraverbals, their senses are extended through the spoken words of others; thus they can vicariously experience what others tell them. Complex intraverbals allow them to learn about the weather, who the new person is on the block, what’s for dinner, the latest information

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about others, and even the experiences that others are having.” (p. 183). However, despite the potential complexity of this repertoire, most research has focused on evaluating teaching procedures for relatively simple intraverbal responses (e.g., Ingvarsson & Hollabough, 2011; Kodak, Fuchtman & Paden, 2012).

Autoclitics are defined as verbal responses for which the primary source of control is the speaker’s own verbal behavior, and Skinner (1957) outlines several different potential types of autoclitics, all of which function in some way to modify the response of the listener with respect to the speaker’s verbal behavior. This includes autoclitics that describe the source (e.g., “I read today that...”) or strength (e.g., “I am certain...”) of the speaker’s statement, as well as assertion and negation (e.g., “It is...” vs “It is not raining.”). Grammar and syntax are also described as autoclitic responding, and grammatical tags (e.g. -s for plurals, -ed for past tense) have been considered as autoclitic “frames” (e.g., Speckman, Greer & Rivera-Valdes, 2012). There are very few applied studies on autoclitics, perhaps in part because these operants are not emphasized in early intervention verbal behavior programs due to their more advanced nature (Sundberg, 2004). Howard and Rice (1988) taught preschool children (age 4-5) qualifying autoclitic responses (also termed “autoclitic tacts”) with respect to degrees of difference/similarity, in the only published study examining this skill in an applied setting with children. The children were first taught to tact particular items, and then were shown distorted examples of the items and were provided with multiple exemplar training of autoclitic tacts of the “weakness” of those examples (e.g., describing a distorted square figure as, “like a square”). This structured training resulted in a generalized autoclitic tact repertoire, with all children being able to use the autoclitic phrases with novel samples, and with one of the children coming up with novel autoclitics (e.g., “not a very good H”).

The verbal behavior approach. Sundberg (1977, 1978, 2008a, 2010) was among the first to apply a Skinnerian analysis of verbal behavior to behavioral intervention programs for children with autism. Programs that fall into this category (e.g., Barbera, 2007; Partington, 2006; Sundberg, 2008b) use skills assessments and curricula based on specific repertoires across each of the Skinnerian verbal operants. They also focus on individualized analyses of the motivational variables that impact

teaching sessions, and recommend pairing instructors with reinforcement and capturing and contriving motivating operations for teaching as well as incorporating significant amounts of natural environment training and other naturalistic teaching strategies (e.g., see LeBlanc, Esch, Sidener & Firth, 2006) along with discrete trial training (Sundberg & Partington, 1999). They heavily emphasize mand training, particularly early on in programming, use teaching procedures that mix training on each of the verbal operants, and recommend a progression from tact and listener skills to intraverbals (Sundberg & Partington, 2010). Another hallmark of such programs is a careful analysis of the stimulus control variables responsible for verbal responding, particularly the analysis of defective stimulus control with respect to the defining variables for each verbal operant (Sundberg, 2008).

The verbal behavior approach has a solid conceptual basis in Skinner's (1957) analysis, and as discussed above, an empirical base for teaching specific verbal operants has grown over several decades (Sautter & LeBlanc, 2006). Although concerns have been raised regarding the empirical basis for the verbal behavior model as a comprehensive approach (e.g., Carr & Firth, 2005) given the lack of large-scale outcome research, there is nonetheless some evidence for a curriculum that is based on a Skinnerian analysis of verbal behavior being more effective than a traditional language curriculum with respect to number of words emitted and maintenance of verbal skills over time (Williams & Greer, 1993).

Thus, there is ample evidence for the effectiveness of both Lovaas-based programs and those based on a Skinnerian analysis of verbal behavior for teaching skills to children with autism. However, neither approach provides a conceptually systematic view of remediating what has been recognized as a core deficit for many children with autism: a lack of generativity and flexibility in their language (Greer & Ross, 2008; Lord & McGee, 2001). The next section of this chapter discusses the traditional behavior analytic views of language generativity (often ascribed to processes of response generalization) and introduces the argument that alternative explanations are necessary, which may be better provided by accounts of derived relational responding as will be discussed in depth in Chapter 3.

Linguistic Generativity and Derived Relational Responding¹

Language generativity might be described as the ability to produce sentences never before said, and to understand sentences never before heard—to be able to produce an effectively infinite variety of utterances and be able to understand similarly various utterances. It is fundamental to the development of fully functional communication. Furthermore, social interaction requires an increasingly complex repertoire in this respect on the part of the child. Thus, the development and/or training of language generativity is critical. However, despite its importance, establishing generative language in child populations in whom it is deficient has proven to be a major challenge. As noted in the previous chapter, in the case of children with autism, rote, inflexible responding is a persistent problem in spite of EIBI (Greer & Ross, 2008; Lord & McGee, 2001).

Within the field of EIBI, the appearance of novel responding, typically ascribed to processes of generalization, has always been identified as of critical importance. According to Lovaas (1981), for example, “[s]ome degree of generalization, be it stimulus or response is critical for successful teaching. You have to get some changes ‘for free’ because you cannot build all behaviors in all situations” (p. 110). As another example, Williams and Williams (2010) suggest that, “stimulus and response generalization are primary reasons why human beings do not have to be taught every response and under every circumstance in which the response should occur.” (p. 85). The term “generalization” is of course also applied in the more specific context of the emergence of novel verbal responding (e.g., Kelley, Shillingsburg, Castro, Addison & LaRue, 2007; Koegel, Camarata, Valdez-Menchaca & Koegel, 1998; Sweeney-Kirwan, 2008; Williams & Williams, 2010). For instance, Sweeney-Kirwan (2008) refers to the objective of intraverbal webbing procedures as being “...to teach advanced intraverbal skills which will facilitate response and stimulus generalization and avoid rote responding”.

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Language generativity typically involves novel responding that was not trained, and thus it has been linked more specifically with response rather than stimulus generalization. According to Lovaas (2003), for instance, "...we had hoped that once the children learned to talk, they would develop the kind of response generalization that would 'push them over' into normalcy" (p. 16). In addition, the research literature on emergent verbal behavior skills often uses the term response generalization in an explanatory capacity (e.g., Goldsmith, LeBlanc & Sautter, 2007; Noell, Connell & Duhon, 2006; Wesolowski, Zencius, McCarthy-Lydon & Lydon, 2005). As another example, Sundberg (2008a) describes the failure to show response generalization as a critical barrier to children's progress in language:

The second type of generalization is response generalization. Here, a child may learn one response under the control of one stimulus (e.g., saying "cat" when asked to name an animal), but fail to provide any other responses that would be considered appropriate under that same stimulus (e.g., the response "rabbit" would also be considered a correct response to the question). The failure to demonstrate response generalization is often part of what is often identified as "rote verbal responding." A child always gives the same answer to questions, despite the fact that there could be many variations to what would be considered a correct answer. (p.118)

The importance of novel or untrained responding as a critical progress marker is also acknowledged within widely employed assessment tools such as the *Verbal Behavior: Milestones Assessment and Placement Program* (VB-MAPP; Sundberg, 2008b) and the *Assessment of Basic Language and Learning Skills* (ABLLS; Partington & Sundberg, 1998). In these assessments also, such responding is explicitly referred to as response generalization. Consider the following items for example:

Shows response generalization for 5 items (i.e., tacts the same stimulus with two different words teacher and Katie; cat and Garfield; dog and Maggie). (Sundberg, 2008b, p. 46)

Shows response generalization by describing the same 10 objects, events, pets, people, etc. in 3 different ways (e.g., in reference to a pet dog Toby, the child says at different times a dog, an animal, Toby). (Sundberg, 2008b, p. 67)

Generalized response forms: The student will be able to use other appropriate responses after learning a response to a given situation...Upon seeing a dog, the student may say "dog", "puppy", "K-9", "pooch", etc. When answering a

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question regarding “things to eat”, the student may say “apple, banana, bread” OR “cake, pizza, apple”. (Partington & Sundberg, 1998, p. 62)

As with the quotations from Lovaas (2003) and Sundberg (2008a), these excerpts suggest both the importance of generativity itself as well as of the phenomenon of response generalization as the process underlying it.

Thus, response generalization seems to be recognized as a key process that underlies language generativity. The fact that this process has been recognized as such would seem to suggest that behavior analysts have an agreed understanding of the latter at a technical level, which should in turn facilitate continuing incremental progress with respect to prediction and influence in the applied domain. However, as has been pointed out, progress with respect to language generativity seems to have been extremely limited. To consider why this might be the case, it is appropriate to consider the concept of response generalization. As will be argued, there has been a lack of agreement on a definition and none of the core definitions seem consistent with the phenomenon to be explained.

Definitions of Response Generalization

Kazdin (1994) cites Skinner’s (1953) conceptualization of response generalization as a process in which “reinforcement of a response increases the probability of other responses that are similar [to that response]” (p. 54). After providing this definition, Kazdin explicitly highlights the importance of physical similarity as the central feature of this phenomenon. Furthermore, he suggests that use of the term response generalization to explain the emergence of nontargeted responses that are not physically similar to a previously trained response is typically incorrect.

More recently, Mayer, Sulzer-Azaroff, and Wallace (2011) provided the following definition of response generalization:

The spread of effects to other classes of behavior when one class of behavior is modified by reinforcement, extinction and so on. The shift in the form or topography of a behavior. For instance, the way a particular letter is shaped or formed may vary in ways that are similar but not identical to the formation of the letter as it was originally reinforced. (p. 698)

Thus, in both these cases, response generalization is defined as involving physically similar responses. Given this definition, however, many if not most examples of language generativity that response generalization is being used to explain cannot be examples of the latter because there is no obvious physical similarity between the novel response and any previously reinforced responses.

For instance, in the example of language generativity in Partington and Sundberg (1998) provided above, a student was said to produce a variety of topographically different responses upon seeing a dog including “dog,” “puppy,” “K-9,” “pooch,” etc. The idea is that the child was taught to name a stimulus and then produced one or more novel names for that same stimulus that were physically dissimilar to the one formally taught. However, such a pattern cannot be accounted for as response generalization if physical similarity between trained and untrained emergent responses is an essential prerequisite. Of course the authors of Partington and Sundberg (1998) might argue that their use of the term response generalization in this context does not refer to a process that relies on physical similarity but as such this use would not cohere with the definitions just provided, which suggests a lack of intradiscipline consistency in this regard, an idea upon which we will shall expand.

Many other approaches to the concept of response generalization also at least imply the importance of physical similarity. Catania (2007), for example, equates response generalization with induction, which he defines as “the spread of the effects of reinforcement to responses outside the limits of an operant class” (p. 393) and he provides an example of this latter process in which the spread of effects is obviously based on physical similarity. Austin and Wilson (2002) suggest that response generalization happens “when reinforced responses co-vary with similar but unreinforced responses” (p. 42) and they cite Catania’s example to support the contention that the process is based on physical similarity.

Despite the fact that many accounts of response generalization suggest physical similarity as a core aspect of it, not all accounts do, as just hinted at in respect of the usage by Partington and Sundberg (1998). For example, some include physical similarity as a possible process but also explicitly suggest other possibilities. In Martin and Pear (2011), for example, response generalization is

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defined as a phenomenon that “occurs when a behavior becomes more probable as the result of reinforcement of another behavior” (p. 193). They then go on to suggest that “response generalization occurs for several reasons” including “unlearned response generalization due to considerable physical similarity, ...learned response generalization based on minimal physical similarity... [and] learned response generalization due to functionally equivalent responses” (p. 193). In the case of the latter two categories, some examples given are, respectively, use of the letter “s” to tact plurality in novel cases after being taught to do it in one or more particular cases, and being able to start a campfire in a variety of different ways, having learned functionally equivalent responses. In the case of the first of these, this is arguably an example of recombinative generalization, (e.g., Suchowierska, 2006) and is discussed in Martin and Pear as an example of the result of training sufficient response exemplars. With respect to the latter, Carr (1988) has also argued for functional equivalence as a possible process underlying response generalization.

By including these latter processes under the umbrella term response generalization, these authors are taking a different stance on the conceptualization of this phenomenon than some of the previous ones. One way in which they are doing so is by including a variety of different processes in their conceptualization. It might be argued that they are diluting the meaning of this term by doing so. A possible counterargument is that it is appropriate to define a term such as this so as to include a relatively broad range of phenomena. Nevertheless, in either event, this suggests that there is some disagreement with respect to the conceptualization of response generalization. Even if it is agreed that the latter need not always be based on physical similarity alone, the fact that there is disagreement with respect to the meaning of the term is problematic, because when it is used as an explanation for examples of generativity, it is unclear which basic behavioral phenomenon might be at issue.

A similar criticism also applies if response generalization is being used as an umbrella term, as in Martin and Pear (2011), because even if it was universally agreed that the term should be used in this way, ultimately, if sufficient precision was required, it would still be necessary to specify which particular process was relevant

in any particular context. In this case, perhaps we might concede that the use of the term might be appropriate so long as it was subsequently specified which subcategory of response generalization was at issue. However, even granting that this might be the case, the processes additional to generalization based on physical similarity that Martin and Pear actually suggest do not seem adequate to explaining language generativity. As indicated previously, these additional categories are explicitly described as being “learned” and thus this explanation would seem to have limited scope as regards the explanation of generativity, which concerns untaught novel behavior.

Cooper, Heron, and Heward (2007) provide a definition of response generalization that is similar in certain respects to that provided by Martin and Pear (2011). According to this definition “[r]esponse generalization is the extent to which a learner emits untrained responses that are functionally equivalent to the trained target behavior” (p. 620). They also provide a number of examples. Their definition is similar to that provided by Martin and Pear (2011) in that it includes, but is not limited to, examples based on physical similarity. A number of the examples that they subsequently give seem to be based on physical similarity, but one is quite obviously not based on it. The latter, which involves alternative and physically dissimilar ways of taking phone messages, is similar to the campfire example given by Martin and Pear. Thus, ultimately, as regards the explanation of generativity, the same comments as made with respect to the Martin and Pear conceptualization of response generalization apply.

Language Generativity and Response Generalization

Language generativity has proven a major challenge because for a long time behavior analysis has not had an adequate theoretical explanation of this phenomenon (cf., Malott, 2003). Furthermore, it can be argued that the use of the term response generalization in relation to this phenomenon has not been helpful in this respect. Though this term seems to promise a technical understanding of the phenomenon at issue, an examination of definitions and approaches to response generalization that appear in the literature suggests that it does not do so. Instead, the

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use of this term to cover a wide variety of emergent language behavior has obscured the potential processes involved, and has not helped lead to the development of procedures for actually programming for generativity.

In fact, this is not the first critique of the use of the term response generalization within the field. For example, in discussing its use as an explanation of novel behavior more generally, Alessi (1987) suggested, “the term seems to denote a kind of magical process, used as an explanatory fiction. Novel responses are said to be products of ‘generalization’ from previous learning, with little regard for the complexity of the responses emitted, and without elaboration of the behavioral principles that might underlay such a process” (p. 16). Similarly, Drabman, Hammer, and Rosenblum (1979) state, “[t]he omnifarious nature of this definition underscores the need for more descriptive labeling or categorization of generalized effects, so that researchers may communicate more clearly, and more discrete analyses of the important parameters involved may be performed. The current practice of subjective reference to a variety of phenomena as generalization is unacceptable if a technology for programming these effects is to be developed” (p. 204).

In summary, then, though the term response generalization seems to promise a technical understanding of the phenomenon of language generativity at a process level, the above investigation of definitions and approaches to this term that appear in the literature suggests that it does not do so. This indicates that behavior analytic science and practice might look further afield for an understanding of this critically important phenomenon. For both theoretical and empirical reasons, a more promising candidate for the role of key processes underlying language generativity seems to be derived relational responding. Thus, in the next chapter, empirical and theoretical work on derived relational responding (DRR) will be examined including literature on DRR applications for teaching language to individuals with autism and other developmental disabilities.

Chapter 3

Derived Relational Responding: Applications and future directions for teaching individuals with autism

This chapter includes work that has been previously published as:

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DRR Teaching Applications

As noted in the previous chapter, impairments in communication are core diagnostic features of autism spectrum disorders (ASD). As such, one of the critical components of effective intervention programs for children with ASD is a focus on teaching language skills, and as also discussed in the previous chapter, behavior analytic approaches to the treatment of ASD typically place an emphasis on the analysis and development of such skills (e.g., see Sundberg & Michael, 2001). However, despite decades of research that have established the effectiveness of applied behavior analysis as an intervention for ASD (e.g., see Makrygianni & Reed, 2010; National Autism Center, 2009), and the marked success of programs that have resulted in many children progressing to the point of age-typical language and academic skills (e.g., Butter, Mulick, & Metz, 2006; Perry, Cohen, & DeCarlo, 1994; Lovaas, 1987), a substantial number of children continue to require ongoing intensive teaching to learn new vocabulary and concepts, and their language skills remain “rote”. It appears that these children fail to develop generative language—that is, verbal behavior that involves producing and understanding sentences never heard or said before (Greer & Ross, 2008; Malott, 2003).

This suggests that linguistic generativity is critically important but that behavior analysis has historically lacked an effective understanding of this phenomenon. More recent developments in the area of derived stimulus relations research, however, seem promising with respect to providing a conceptually systematic foundation and explanation for the phenomenon of generative language. This area of research, with its emphasis on the emergence of novel, untrained responses, has begun to identify a promising set of procedures for teaching generative verbal behavior (e.g., Rehfeldt & Barnes-Holmes, 2009). The purpose of the current chapter is to provide a theoretical background to derived stimulus relations, mainly using Relational Frame Theory (RFT; Hayes, Barnes-Holmes & Roche, 2001), and also to review research in this area that is applicable to teaching language to individuals with ASD or other developmental disabilities. Based on this review, a number of general recommendations are given for teaching and curricular

sequencing principles, assessment strategies, and areas for future research. Some of these form the basis of the work presented in this thesis, which aims to further the research on establishing very early repertoires of derived relational responding (DRR) when such skills are weak or nonexistent—in particular, skills that are critical for the development of early language and conversation: derived relations among auditory and visual stimuli.

Derived Equivalence

The most prominent empirical example of derived relational responding is stimulus equivalence, which was first demonstrated in Sidman's now classic 1971 study that involved teaching reading to a young man with a learning disability. At the outset of the study, for a particular set of stimuli, the participant could emit spoken words (A) given pictures (B), and could select pictures (B) given spoken words (A); and in the initial part of the study he was taught to select printed words (C) given spoken words (A). However, he subsequently showed several additional untaught or derived performances, including saying appropriate spoken words (A) given printed words (C), matching pictures (B) to printed words (C), and matching printed words (C) to pictures (B). As such, he was responding as if particular sets of spoken words, pictures and printed words were the same as or equivalent to each other and thus Sidman termed this pattern of responding *stimulus equivalence*.

Based on these results and subsequent empirical data, Sidman suggested that stimulus equivalence is defined by three emergent relations, namely, *reflexivity*, ($A=A$), *symmetry* (if $A=B$ then $B=A$) and *transitivity* (if $A=B$ and $B=C$, then $A=C$). An additional feature of stimulus equivalence known as *transfer of functions* has also been demonstrated (e.g., Dougher, Augustson, Markham, Greenway & Wulfert, 1994) whereby the behavioral functions of a given stimulus (e.g., discriminative [e.g., Dymond & Barnes, 1995] or eliciting [e.g., Dougher, et al. 1994]) transfer, without additional training, to other stimuli that participate in a relation of equivalence with the first stimulus. For example, if a child is taught to derive a relation of equivalence between the spoken and written words “cat” and an actual cat, then some of the stimulus functions of the latter may transfer to each of the two

former such that, for example, the written or spoken word “cat” may now evoke an image of a small furry animal.

The phenomenon of responding in accordance with stimulus equivalence has generated interest and debate within behavior analysis for a number of reasons. It is not predicted by traditional operant theory, in that the derived symmetrical and transitive response relations do not have the history of reinforcement that would be needed to establish conditional discriminations (Barnes, 1994). In addition, it has practical advantages since the fact that not all relations need be taught directly means efficiencies in terms of time and effort. Perhaps most importantly, it seems closely linked with human language. For example, in terms of its characteristics, it possesses several key features that are language-like including bi-directionality (i.e. this is the feature whereby relationships between stimuli are in both directions so that when one learns a response in one "direction," such as selecting a cup when someone says "cup", there will be automatic derivation of the relation in the other "direction" such as saying "cup" in the presence of a cup) and generativity (Fields, Verhave & Fath, 1984). Furthermore, a range of empirical evidence supports the link between stimulus equivalence and language. One line of evidence has come from the contrast between verbal and non-verbal organisms with respect to the demonstration of derived relational responding such as equivalence relational responding . In typically developing humans, level of derived equivalence performance is correlated with level of language performance (e.g., Lipkens, Hayes & Hayes, 1993) while humans with absent or delayed language repertoires tend to be unable to respond in accordance with equivalence (e.g., Devany, Hayes & Nelson, 1986) and the evidence for derived equivalence in non-humans is scant and at best disputable (e.g., Dugdale & Lowe, 2000; though see also Schusterman & Kastak, 1993). The link between equivalence and language is also supported by the results of neuroscientific research demonstrating that brain activity measured during derived relational responding tasks resembles that seen during language performance (e.g., Dickins, et al., 2001; Ogawa, Yamazaki, Ueno, Cheng & Iriki, 2010).

Relational Frame Theory

The empirical link between derived relational responding (such as is seen in stimulus equivalence) and language is particularly intriguing and exciting for behavior analysts. As such, a number of theories have been advanced in an attempt to explain the link (e.g., Hayes, Barnes-Holmes & Roche, 2001; Horne & Lowe, 1996; Lowenkron, 1998; Sidman, 1994, 2000). The most empirically well supported of these by this point is Relational Frame Theory (RFT; Barnes-Holmes, Y., Barnes-Holmes, D., Roche & Smeets, 2001a, 2001b; Dymond & Roche, 2013; Hayes, 1991, 1992; Hayes et al., 2001) and accordingly, this is the approach largely used as the theoretical background to this review and to the current line of research.

Relational Frame Theory suggests that the empirical association between derived equivalence and language comes about because they are essentially the same phenomenon, namely *generalized contextually controlled arbitrarily applicable relational responding* (or more simply, *relational framing*). Relational responding involves responding to one stimulus in terms of another (e.g. Hayes, Fox et al., 2001, p 25). Moreover, such responding is generalized and is in accordance with a relational pattern, rather than only one or a limited number of associations (e.g., Stewart & McElwee, 2009).

Many species, including humans, demonstrate generalized relational responding based on physical properties of the relata (e.g., picking an object that is physically the same as another object, as in identity matching, or picking something that is physically larger or smaller than something else), referred to as *non-arbitrary* relational responding (e.g., Hayes, Fox et al., 2001; Reese, 1968; Stewart & McElwee, 2009). However, RFT posits a further type of generalized relational responding: *arbitrary* (or *arbitrarily applicable*) relational responding is responding to stimuli as being related in a particular way not based on the physical characteristics of those stimuli but instead, dependent primarily on *contextual control*. For example, a *non-arbitrary* sameness relational response can be seen if a young child matches a picture of a previously unseen animal (perhaps a lemur) to another picture of that same animal. To illustrate *arbitrary* sameness relational responding, imagine I tell that child that the sound “Lemur” (A) is the name of the

animal in the picture (B) and also that the written name for “Lemur” is the textual stimulus “Lemur” (C). Without further training, she might then derive further relations (e.g., that the picture B goes with the textual stimulus C and vice versa) as part of an overarching pattern in which all three stimuli, A, B and C are treated as mutually substitutable or equivalent, despite the fact that they are not physically the same. This pattern of arbitrary sameness responding can be brought to bear by linguistic cues such as the phrases “is,” “called,” or “name of” as well as by more subtle cues such as the use of a Matching-to-Sample (MTS) procedure (which has been employed to study this pattern in the laboratory). From the RFT perspective, moreover, sameness is only one type of derived relational pattern. As another example, in the case of a difference relation, one might be asked to “Pick up some takeout dinner on the way home from work, but get something *different* from last time—I’m tired of Thai food”. Based on the inclusion of the “different” cue, this request would likely evoke a comparison by the listener of the available takeout options, and the selection of one that is something other than Thai food, whether or not that particular selection had been tried before. Social contingencies might further condition responding; for example, delivery of Thai food might result in criticism and an argument while delivery of something other than Thai food might be met with approval.

RFT theorists argue that the reinforcement history that has led to this type of relational responding is what underlies an organism’s ability to respond in accordance with a pattern of stimulus equivalence as well as other relational patterns of responding. Over the last two decades, RFT researchers have provided empirical evidence for a variety of patterns of derived relations in addition to sameness including *distinction* (e.g., Roche & Barnes, 1997), *comparison* (e.g., Berens & Hayes, 2007), *opposition* (Barnes-Holmes, Barnes-Holmes & Smeets, 2004), *analogy* (e.g., Stewart, Barnes-Holmes, Roche & Smeets, 2004; Persicke, Tarbox, Ranick & St. Clair, 2012), *temporality* (O’Hora, Barnes-Holmes, Roche, & Smeets (2004) and *deixis* (McHugh, Barnes-Holmes, & Barnes-Holmes, 2004) and RFT proponents argue that this variety of relational patterns or frames underlies the diversity, complexity and generativity of human language. Further research is of

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course needed to fully explore this hypothesis and to gauge the patterns of development of the diverse frames involved as well as their interaction, but RFT research has at least started to make useful inroads in this respect (see Dymond & Roche, 2013, for an overview of recent research).

Two characteristics of derived arbitrarily applicable relational responding or relational framing that seem particularly important from the current perspective are that it is extremely generative and that it can be trained. Evidence for the generativity of this behavior has been provided by many of the RFT studies that have appeared in the literature thus far, though a few in particular deliberately highlight this characteristic (e.g., Wulfert & Hayes, 1988; O'Hora, Barnes-Holmes, Roche, & Smeets, 2004; Stewart, Barnes-Holmes & Roche, 2004). For example, Stewart et al. (2004) used an RFT-based procedure known as the relational evaluation procedure (REP) to establish abstract shapes as contextual cues for SAME and DIFFERENT relational responding and for TRUE and FALSE responses, respectively, and then employed these cues both to model analogical reasoning as the relating of derived relations between derived relations as well as to demonstrate that an in-principle infinite number of new analogical relations was possible based on this technique.

As an operant, relational framing itself is learned and can be trained. That is, in addition to using relevant stimulus arrangements to establish contextual control over new conditional discriminations (and thereby capitalize on the wealth of emergent relations that result), as described above, the ability to derive relations of various types can be trained when such responses do not emerge following appropriately arranged conditional discrimination training. RFT proponents have argued that framing is learned naturally by typically developing children via everyday language interactions during which they are exposed to contingencies that establish these response patterns (e.g., Lipkens et al., 1993; Luciano, Gómez & Rodríguez, 2007). From this perspective, caregivers provide children with multiple exemplars for appropriate responding in accordance with particular stimulus relations. Consider, for example, the very early history of training responsible for establishing sameness (coordination) relations between a word and an object. Caregivers will often utter the name of an object in the presence of an infant and then

reinforce any orienting response that occurs towards the particular object (hear name A ◊ look at object B). They will also often present an object to the infant and then model the name of it, and reinforce echoic responding in the presence of that object (see object B ◊ hear and say name A). RFT suggests that after a sufficient number of name-to-object and object-to-name exemplars have been taught, the generalized operant of symmetrical object-name responding is established. Effectively, the multiple-exemplar bi-directional training establishes particular contextual cues as discriminative for symmetrical responding. For instance, imagine that a child with such a history is told, "This is a teddy." Contextual cues, including the word "is" and other aspects of the naming context (such as the presence of the caregiver, pointing to objects, and so on), will now be discriminative for symmetrical responding between the name and the object. Thus, without any additional training, the child will now not only answer, "teddy" when presented with the teddy and asked, "What is this?" (object B ◊ name A), but will also derive the response of pointing to the teddy when asked, "Where is the teddy?" (name A ◊ object B).

Relational frame theory argues that such multiple exemplar training (MET) also enables responding in accordance with a pattern of stimulus equivalence. Similar to the way in which a child can learn symmetrical responding through exposure to the socio-verbal environment they may also learn more complex relations involving three or more stimuli. When first learning sight words, for instance, an individual might be explicitly taught that a picture (A), an auditory stimulus (B) and a textual stimulus (C) "go together" so that they are mutually substitutable for each other in certain contexts such that the selection of any one of the three in the presence of either of the others will produce reinforcement. After sufficient exemplars of groupings of three or more mutually substitutable stimuli such as this, the child may begin to derive transitive relations based on being taught two of the symmetrical relations in a novel grouping. For example, having been taught that a picture of a dog (A) should be selected with the spoken word "dog" (B) and that the textual stimulus "dog" (C) should also be selected with the spoken word (B), they may then, without additional reinforcement, choose the picture (A) with the textual stimulus (C) and vice versa.

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Hence, relational framing is seen as a generalized or overarching response class generated by a history of reinforcement across multiple exemplars, and once established any stimulus or response event, irrespective of form, may participate in a relational frame. The above example suggests how framing is learned through natural language interactions. However, over the last decade a number of RFT studies have provided empirical demonstrations of the use of MET as a means of deliberately training framing repertoires in young children for whom they are deficit or absent. For example, Barnes-Holmes, Barnes-Holmes, Smeets, Strand & Friman (2004) and Barnes-Holmes, Barnes-Holmes & Smeets (2004) trained repertoires of “more/less” and “opposite” relational framing, respectively, in young children aged between 4 and 6 when they were found to be absent; Luciano et al. (2007) trained a young infant whose age ranged from 15-23 months during the study to respond in accordance with stimulus equivalence; while Berens and Hayes (2007) and Weil, Capurro & Hayes (2011) provided multiple baseline demonstrations of the training of comparative and deictic frames, respectively, in 4-5 year olds.

While there are many different forms or patterns of relational framing from the RFT perspective, they all share three core properties: mutual entailment, combinatorial entailment and transformation of stimulus function. These properties are analogous to those of symmetry, transitivity, and transfer of function, which are found in the case of stimulus equivalence, but they are broader, more generic concepts that can be applied to relations other than sameness or coordination.

Mutual entailment involves learning a relation between two items in one direction ($A \rightarrow B$) and then being able to respond in the other direction ($B \rightarrow A$) without specific teaching (i.e., deriving the relation). The naming example above demonstrates this for a frame of sameness, while with other types of frames, the relation is derived in accordance with the frame; for example, if A is bigger than B, then B is smaller than A; if A is above B, then B is below A, and so on.

Combinatorial entailment involves combining two stimulus relations (trained or derived) to get a third: if $A \rightarrow B$ and $C \rightarrow B$, then $A \rightarrow C$ and $C \rightarrow A$. For example, having learned that a bat goes with a ball, and that a glove goes with a ball, a child may then put the bat and the glove together without having been taught to do so. As

in the examples for mutual entailment, the relation is derived in accordance with the frame: in a frame of opposition, for example, if A (e.g., “Hot”) is the opposite of B (e.g., “Cold”), and C (e.g., “High temperature”) is the opposite of B, then A (“Hot”) and C (“High temperature”) are the same; in a frame of comparison, if a euro is worth more than a dollar, and a dollar is worth more than a ruble, then a euro is worth more than a ruble and a ruble is worth less than a euro; and so on.

The third property of relational framing, transformation of function, is demonstrated when the psychological function of a stimulus is changed or transformed in accordance with the relation between that stimulus and another stimulus in a relational frame. This feature is critically important, as it involves behavior being changed via relational framing. For example, imagine that a child has already learned that she can purchase an item in the store with a particular coin and is then told that another, previously unseen coin is worth more than the first one. A child who has a sufficient repertoire of comparative relational framing will be able to respond in accordance with this relation and the reinforcing function of the second coin will be transformed so that it becomes more appetitive than the first. Hence, if given a choice, the child will likely ask for the second, novel coin, in preference to the first, despite having only received reinforcement in the presence of the first.

From the current perspective, derived relational responding, with its properties of mutual and combinatorial entailment and transformation of functions is the key process underlying generative language. The purpose of this review is to examine two primary areas of research: a) studies that have established derived relational responding when absent, and b) studies that have used the derived relational responding paradigm to efficiently expand various behavioral repertoires. Rehfeldt (2011) recently reviewed the literature on relational responding as published in the *Journal of Applied Behavior Analysis*, and made a number of important suggestions for the future of this area of research which will be returned to throughout this review.

As described above, RFT provides a coherent and thorough framework for understanding derived relational responding and how it relates to generative language and accordingly the RFT conception of derived relational responding as

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relational framing will provide the theoretical direction for this review. At the same time, as well as citing RFT research on derived relations this review will also refer to the work of behavior analytic researchers who adopt theoretical positions on derived relations other than RFT (e.g., Horne & Lowe, 1996), as their work is very valuable both in terms of the data that they provide as well as in terms of their contribution to theoretical debate concerning derived relations and language (e.g., Greer & Ross, 2008; Miguel, Yang, Finn & Ahearn, 2009; Luciano, Rodríguez & Mañas, 2009). Most importantly, the benefits of incorporating relational responding into behavioral educational curricula for individuals with developmental disabilities will be highlighted throughout this chapter.

Derived Relational Responding: Two types of studies

This chapter has now provided the key theoretical and empirical background to the phenomenon of derived relational responding. As described, from an RFT perspective, derived relational responding or relational framing is a generalized or overarching operant response class generated by a history of reinforcement across multiple exemplars, and its development underlies the development of language and complex abilities (e.g., problem solving, planning, reasoning etc.). In the next section, studies will be reviewed on derived relational responding that are directly relevant with respect to the application of this phenomenon in the educational arena, and in particular to teaching generative language to young children with ASD (or other developmental delays).

Although many individuals with ASD may perform successfully in tasks involving derived relations, others may not (McLay, Sutherland, Church & Tyler-Merrick, 2013). In fact, one of the core problems for many individuals with ASD or other developmental delays is that their relational framing/derived relational repertoires are either markedly deficient or absent (see, e.g., Devany et al., 1986; McLay et al., 2013). In such cases, establishing derived relational responding is critical in order to establish generative verbal behavior. Therefore this review begins with studies that aimed to establish repertoires of derived relational responding from the bottom up, through multiple exemplar training. Since such repertoires are so

fundamental to the development of generative language, establishing them using appropriate interventions (e.g., MET) is of critical importance. Empirical work in this area is less advanced than work capitalizing on pre-existing derived relational repertoires; although there is some work establishing such repertoires, it has mainly (though not exclusively) been carried out with typically developing participants. At the same time, the work that has been conducted suggests the potential and promise of such interventions for remediating the absence of linguistic generativity.

On the other hand, many children with ASD do have at least a basic repertoire of derived relational responding, such as responding in accordance with stimulus equivalence/frames of coordination, which has been acquired through exposure to natural socioverbal contingencies. Though perhaps not as well practiced or advanced as that of typically developing children, this ability nevertheless can be used and built upon in order to expand their repertoire of skills and responses more rapidly and efficiently than would be possible through more conventional training. Many studies of derived relational responding, including the seminal study by Sidman (1971), have capitalized on this type of potentially generative repertoire to rapidly expand the linguistic and behavioral repertoires more generally of those with developmental delay. The participants in such studies readily demonstrated derived relational responding once they had acquired the necessary conditional discriminations (i.e., when assessed, they were able to respond in accordance with the predicted derived relational pattern, typically stimulus equivalence). In other words, their generalized ability to demonstrate derived relational responding appears to have already been established and the interventions described capitalized on this ability. The educational relevance of this approach is significant and it offers substantial benefits, as will be reviewed below.

With respect to both of these areas of need—establishing derived relational responding when absent, and capitalizing on existing skills—it is clear that any comprehensive behavior analytic educational program will need to take an approach incorporating functional assessment and appropriate goal setting. That is, practitioners must be able to determine what skills are lacking, and which of those skills might constitute behavioral cusps that would then allow for rapid

generalization and additional skill acquisition. This need for functional assessment of existing repertoires of derived relational responding will be addressed in the concluding discussion of this chapter.

Establishing Derived Relational Responding

First, the growing body of research showing the establishment of derived relational responding will be examined. This research is primarily in the applied work based on Relational Frame Theory; other approaches such as Naming theory (Horne & Lowe, 1996) and Verbal Development Theory (Greer & Speckman, 2009) have also contributed to the literature on derived relational responding albeit from a different theoretical position, which will be discussed below. The RFT conceptualization of derived relational responding as a higher order operant behavior outlines a clear learning pathway for these skills. From this point of view, MET in relational responding skills is not only seen as the means by which typical children develop language skills, but also suggests the means of remediation and training of such skills when they are absent. As stated earlier, RFT proposes that there are many different contextually controlled relational patterns of responding. Skills within several different patterns, or *frames*, of derived relational responding have been targeted for remediation in both typically developing young children and individuals with ASD and other developmental disabilities; relational skills trained have included coordination (Luciano et al., 2007; Murphy, D. Barnes-Holmes & Y. Barnes-Holmes, 2005), comparison (Barnes-Holmes et al., 2004; Berens & Hayes, 2007; Gorham, Y. Barnes Holmes, Barnes-Holmes & Berens, 2009; Murphy & D. Barnes-Holmes, 2010), opposition (Barnes-Holmes et al., 2004), and perspective taking (Rehfeldt, Dillen, Ziomek & Kowalchuk, 2007; Weil et al., 2011). In what follows, empirical examples of the training of these frames will be reviewed.

Teaching the frame of coordination. The pattern of derived relational responding that characterizes the classic pattern of stimulus equivalence in which stimuli are “substitutable” for one another is often termed a frame of sameness or coordination within RFT. Across the literature there is a relative paucity of research (with either typically developing or developmentally delayed populations) that looks

at remediating absent relational framing skills through explicit training. The frame of coordination is particularly difficult to examine empirically with respect to procedures for training individuals to respond in accordance with this pattern when they do not already readily demonstrate such derived relational responding, because this repertoire appears to develop quite early in typical language development. For example, Lipkens et al., (1993) examined the emergence of the frame of coordination in a young typically developing child (age 16-27 months over the course of the study). He could derive mutually entailed picture-name relations as early as 17 months, and combinatorially entailed name-sound relations by 24 months. Thus, populations that would be expected not to have this skill already are restricted to infants or young toddlers and individuals with significant developmental disabilities. Nevertheless, there are already several studies whose work can be considered relevant to the establishment of coordinate framing—at both mutual entailment (symmetry), and combinatorial entailment (transitivity) levels.

Luciano et al. (2007) assessed and trained a very young child (age 15 months at the outset of the study) who did not initially show receptive symmetry, which was defined as the untrained ability to select a requested object from an array, after that object had previously been labeled (using a nonsense word) by the experimenter. That is, if the experimenter gained the child's attention and then presented an item, saying, "This is [x]", the child was initially unable to later select object [x] from an array. MET in object-sound/sound-object relations with 10 different stimuli was then provided. First, an object (A) was presented, and then vocally labeled (B) by the experimenter (i.e., A-B relations), and then (after progressively longer delays) training was provided in the selection of the object from an array (i.e. B-A relations). Following training, the child could show delayed receptive symmetry with novel objects; that is, she could select a specified item from an array (B-A) for a novel item that had been previously (with a delay) shown to her and labeled by the experimenter (A-B). After subsequent training in visual-visual conditional discriminations, she also showed equivalence.

Barnes-Holmes, Barnes-Holmes, Roche and Smeets (2001a, 2001b) examined the development of action-object symmetry in typically developing four-

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and five-year-olds. While it would be expected that children of this age would have well-established derived relational responding repertoires, these studies utilized a context with which the children were unfamiliar, thus revealing a gap in their relational repertoires that could subsequently be trained. Rather than using a standard match-to-sample context for training relations, the researchers taught the children to select a particular stimulus in the presence of a particular action, or vice versa (e.g., in some experiments, when the experimenter waved, the child selected stimulus A1, while when the experimenter clapped, the child selected stimulus A2; in other experiments, the child was taught to perform the action in the presence of the particular stimulus). Children were then tested for symmetry, by being required to perform the action in the presence of each stimulus item, or vice versa, depending on which had been trained (e.g., clap in the presence of A1 if training had consisted of selecting stimulus A1 when the experimenter clapped). Across all multiple baseline experiments within the studies, the majority of children failed to demonstrate symmetry when first tested; subsequently, multiple exemplar training (e.g., explicitly teaching the action to perform in the presence of the stimulus item) quickly resulted in the demonstration of symmetry with novel stimulus sets across all children.

Murphy et al. (2005) examined the development of transfer of function through equivalence relations. This study was one of several that have focused on training methods involving both derived relational responding (i.e., the key process characterizing verbal behavior from an RFT perspective) with operant behaviors defined as verbal within a Skinnerian perspective (e.g., manding, tacting and intraverbals; see D. Barnes-Holmes, Y. Barnes-Holmes & Cullinan [2000] for a discussion of the synthesis of these two approaches, which will also further be discussed in Chapter 4). Murphy et al. (2005) combined derived relations with manding (that is, responses that are reinforced by delivery of a specific consequence, and which are therefore under the control of the establishing operations relevant to that consequence [Skinner, 1957; Michael, 1988]) as a means of facilitating a more flexible manding repertoire. They used a token board game to contrive conditioned establishing operations for two differently colored tokens needed to fill the board. Similar to the use of a picture exchange system for manding, abstract stimuli A1 and

A2 were trained to have discriminative functions for manding the two different color tokens respectively. Subsequently, participants were trained in A-B and B-C conditional discriminations, and then tested for their ability to mand using C stimuli (i.e., thus showing transfer of the discriminative functions from A1 and A2 to C1 and C2 respectively, which in this context was termed “derived manding”). Two participants showed transfer of function immediately. The third, who did not do so, was given MET. After directly training transfer of function (i.e., training him to mand using both A1 and C1 stimuli and A2 and C2 stimuli), a novel set of stimuli was used to repeat mand and conditional discrimination training and test for transfer of function. He again failed and then was trained on that set. After MET with three stimulus sets, the participant showed transfer of function with a fourth novel set.

In a unique recent study, Walsh, Horgan, May, Dymond and Whelan (2014), used a computerized variation on traditional match-to-sample formats, the Relational Completion Procedure (RCP), in which the task was to “drag and drop” the correct comparison stimulus into a blank box next to the sample stimulus. In this study, six of the nine participants (all of whom were diagnosed with ASD) were unable to derive relations between text and picture stimuli in accordance with a frame of coordination following initial conditional discrimination training on baseline (A-B and A-C) relations. These participants were then given MET. “Sham” MET (i.e., training in unrelated conditional discriminations) was given to two of the participants in order to control for possible emergence of derivation following repeated exposure to testing stimuli or time on task and this did not result in the emergence of derived relations on new stimulus sets. However, relevant MET did result in the emergence of derived relations on novel stimulus sets for these two participants as well as a third (with the study ending due to time constraints before the remaining participants could complete MET with multiple stimulus sets).

Establishing frames of coordination among auditory and visual stimuli is clearly critical for language development. Thus far, a number of RFT-based studies that have used MET to train coordinate relations have been considered. However, RFT is not the only theoretical approach relevant in this respect. A number of theorists and researchers working outside the RFT paradigm have focused on a

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similar domain via the concept of *naming*. The latter has been defined as the ability to “acquire both the speaker and listener responses to stimuli as a result of observing stimuli while hearing others say the ‘names’...without direct instruction in the form of reinforcement or error corrections” (Gilic & Greer, 2011, p 157). Many researchers see naming as a distinctive and fundamental verbal repertoire (e.g., Horne & Lowe, 1996; Greer & Keohane, 2004; Greer, Stolfi, Chavez-Brown, & Rivera-Valdes, 2005). Furthermore, a number of studies have shown the facilitative effect of naming (as well as the inclusion of stimuli that are familiar/nameable/pronounceable or have other discriminative functions) on the demonstration of equivalence (e.g., Eikeseth & Smith, 1992; Holth & Arntzen, 1998; Horne, Hughes, & Lowe, 2006; Horne, Lowe, & Harris, 2007; Lowe, Horne, & Hughes, 2005; Fields, Arntzen, Nartey & Eilifsen, 2012; though see also O’Connor, Rafferty, Barnes-Homes, D. & Barnes-Holmes, Y., 2011; Luciano et al., 2007). In addition, there are now several studies that have examined how MET might be used to establish this repertoire. From an RFT point of view, naming is an example of mutually entailed name-object relations and more broadly of coordinate relations; hence its empirical link with equivalence. While not considered a distinctive repertoire as such, it is nevertheless of critical importance. Hence, in what follows, in the final part of this section on establishing coordinate relations, studies will be considered that have used MET to attempt to establish naming.

Greer et al. (2005) used MET to establish mutually entailed responding in the form of the listener to speaker component of naming (i.e., being able to name an object based on previously being taught to respond as a listener, such as by selecting the object when it is named) in three children with mild developmental delay who at baseline did not have this repertoire. Baseline probes consisted of teaching the child matching responses using discrete trial presentations where the teacher spoke the name of the picture as the child matched (i.e., name-object; A-B training). Once criterion was met for the matching responses, a probe was conducted for the untaught repertoires—pointing, tacting (i.e., responding under the control of a nonverbal stimulus and generalized nonspecific conditioned reinforcers [Skinner, 1957]) with no teacher provided antecedent and tacting after the teacher asked,

“What is this?” (referred to as “pure” and “impure” tacting respectively). Specifically, these probes tested for the emergence of derived object-name relations (or B-A relations). During these probes, the participants did not demonstrate derived relational responding (i.e., after learning A-B relations they did not mutually entail B-A relations) and thus they were exposed to MET. During MET, they were taught to respond as listeners (matching and pointing-to) and speakers (pure and impure tacting) to two sets of five pictures (i.e., response topographies were rapidly rotated across the teaching session). As a function of this MET, untaught speaker responses emerged after only matching responses were taught for a third novel set of stimuli, consistent with mutual entailment. Fiorile and Greer (2007) subsequently tested whether pure tact (object-name) instruction alone would lead to naming. The four children who participated had severe language delays, had no repertoire of learning tacts through echoic to tact transfer of stimulus control training procedures nor untrained echoic-to-tact transfer and did not demonstrate naming (either speaker to listener or listener to speaker). Pure tact training alone did not result in a naming repertoire or untrained echoic-to-tact responses for these students. MET was provided across matching, speaker (pure tact) and listener repertoires for a subset of stimuli (the teaching set) and this resulted in untaught response components of naming and the capability to acquire naming after learning pure tacts for subsequent sets of stimuli.

Greer, Stolfi and Pistoljevic (2007) replicated the effects of the previous two studies and also isolated MET as the variable that led to the emergence of naming. In this study they compared singular exemplar instruction (SEI) and MET on the emergence of naming in preschool children who were missing the repertoire. Four participants were taught training sets of pictures using MET, in which matching, speaker and listener responses were systematically rotated during instruction, and four other children were taught the same sets using SEI, in which all topographies (matching, speaker, and listener responses) were taught separately from each other, each in 20-trial sessions. The number of instructional presentations was matched for both groups. Naming emerged for the MET group but not for the SEI group. Subsequently, the SEI participants received MET and naming emerged.

Teaching the frame of comparison. A number of studies have examined training relational responding skills other than coordination or equivalence with typically developing young children. Comparison is likely one of the first relations to develop following coordination (see, e.g., Luciano et al., 2009). There is not yet sufficient empirical evidence to determine in exactly what sequence different frames might emerge; however, once a child has a repertoire of coordinate framing, they will probably have a reasonably well developed vocabulary. This is because, as described earlier, RFT suggests that multiple exemplar training involving explicit bi-directional training with an extensive variety of object-name pairs is needed before the acquisition of coordinate framing. As such, the child will likely have learned to tact a significant number of things, and will also be able to rapidly acquire new tacts through derivation. By this point, they also will likely have had exposure to a number of contextual cues for relations such as comparison and difference (which will be discussed in depth in Chapter 7), at a non-arbitrary level (i.e. physical relations between stimuli such as bigger/smaller or same/different). Thus, they will likely be able to do non-arbitrary relational responding while not yet being able to show fully contextually controlled relational framing in which the relational response is independent of the physical properties of the actual stimuli being related.

In comparison relations, the bidirectional relations between stimuli are not symmetrical—for example, mutual entailment would be demonstrated by an individual who, after being taught that A is greater than B, responds that B is less than A. In this example, combinatorial entailment might be probed with the addition of a second trained relation such as “C is less than B”, for example, and testing for the derivation of “A is greater than C” and “C is less than A”. Rehfeldt (2011) points out the relevance of comparative relational responding to many early academic tasks such as telling time, measurement, and basic arithmetic. While each of these skill sets involve different content, they all involve basic relations of comparison between and among the stimuli; hence the same types of relational multiple exemplar training could be utilized for teaching all of them.

Y. Barnes-Holmes et al. (2004) were the first to demonstrate the training of arbitrarily applicable relational responding skills through MET when those skills

were absent, and the specific type of relation involved was comparison. This study used abstract stimuli (paper “coins”) and arbitrarily assigned values (being able to buy “more” or “less” sweets with different coins). Three children, ages 4 to 6, were taught specific relations among “coins” (e.g., $A > B > C$ or $A < B < C$), and were then asked which coin they would or would not bring to the shop to buy as many sweets as possible. For example, at the simplest (i.e. two stimulus level), two paper coins would be placed in front of the child from left to right (A-B), and the experimenter would say, “If this coin [pointing to coin A] buys more sweets than this coin [pointing to coin B], which would you bring to the shop to buy as many sweets as possible?” ($A > B$). Four trial types were presented for AB: $A < B$, $A > B$, $B > A$, $B < A$. For ABC relations, the coins were positioned from left to right (A-B-C) and an additional four trial types were presented: $A < B < C$, $C < B < A$, $A > B > C$, $C > B > A$. All participants failed to respond consistently in accordance with any of these relational tests. Training was then given in the same format, but with correction/reinforcement following incorrect/correct responding. Following extensive training with multiple sets of stimuli (and for one participant, additional training in non-arbitrary comparative relations), all participants were able to demonstrate generalized responding with more than/less than relations.

Berens and Hayes (2007) replicated and extended the previous study, addressing several potential weaknesses of that study, and providing a demonstration of the extent to which MET can result in relational responding within a frame of comparison. Whereas Y. Barnes-Holmes et al. (2004) used relatively short baselines and trained all trial types (thus limiting the ability to determine whether skills generalized to new trial types or simply to novel stimulus sets), Berens and Hayes (2007) tested for generalization following each phase of training, used both linear and nonlinear trial types as described below, and provided for lengthier baselines. In linear combinatorial trial types, the relations trained are all in the same direction when the stimuli are lined up before the participant. For example, given an array of A-B-C, the experimenter might say, “This [pointing to A] is more than that [pointing to B], and this [pointing to B] is more than that [pointing to C]. Which one would you use to buy candy?” These tasks also involved the same trained relation (e.g., in

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the case of the latter example, both trained relations are “more”). Non-linear trial types are more complex both because they involve trained relations that are in two different directions and because the relations themselves are different (i.e., both “more” and “less” are trained). For example, given the array A-B-C, the experimenter might say, “This [pointing to A] is more than that [pointing to B], and this [pointing to C] is less than that [pointing to B]. Which one would you use to buy candy?” As in the previous study, participants were initially unable to respond with consistent accuracy, but following MET they were able to respond correctly across a range of task types. While improvements were greatest on the specific trial types trained, improvements also occurred on untrained trial types, providing additional evidence for relational responding within a frame of comparison as an operant.

This study was conducted with typically developing young children who were not able to demonstrate comparative relational responding. Of particular note for practitioners assessing and training relational responding skills for children with language delays, the study also identified potential prerequisites in the development of comparative relations. As was the case for one participant in the previous study, two participants who initially failed to demonstrate arbitrary comparative relations were also found to be unable to demonstrate non-arbitrary comparative relations (i.e. identifying which pile of pennies had “more” or “less”). Once trained in non-arbitrary comparative relations these participants were successfully trained in the arbitrary comparative relations. Gorham et al. (2009) subsequently replicated and extended this work to children with ASD as well as typically developing children.

In a variation on these studies establishing derived comparative responding, Murphy and D. Barnes-Holmes (2010) examined the development of derived manding via transformation of functions through a frame of comparison, with both typically developing children and children with ASD. In this study, a modification of the token game procedure previously described (Murphy, et al. 2005) was used first to establish manding using stimulus cards (nonsense CVC words/text) for specific amounts (+2, +1, 0, -1, -2) of tokens (smiley faces), in order to correctly fill up the token board. Other stimuli (abstract shapes designated X and Y) were then established as contextual cues for “more” or “less” relational responding by teaching

the selection of lines of either a greater or fewer number of smiley faces in the presence of each. Baseline conditional discriminations were then trained to establish comparative relations between a novel set of A/B/C/D/E stimuli (e.g., $A > B$, $B > C$, $C > D$, $D > E$), using the X/Y stimuli as contextual cues for selecting the appropriate stimulus (the one that is “more” or “less” than the other). Participants were then taught to mand for either +1 or -1 tokens to play the token game, and were subsequently tested for derived mands for +2 or -2 tokens. Five of the seven participants in this study could show transformation of function without training (and were able to demonstrate derived mands when the order of A-E stimuli was reorganized). For the two participants who were not able to immediately demonstrate transformation of functions, the functions were directly trained, by teaching the participants to mand with the appropriate stimuli. After MET with two sets of stimuli, these children were then able to demonstrate derived manding with a novel stimulus set.

Teaching the frame of opposition. In Y. Barnes-Holmes et al. (2004), typically developing 4 to 6 year old children were tested and then trained to respond in accordance with frames of opposition, again using a game in which arbitrary “coins” were assigned value. In this case, children were told that a particular coin bought “many” or “few” sweets, and then told that another coin was “opposite” to that coin, for a sequence of 4-10 coins (e.g., $A = \text{many}$, A is opposite B , B is opposite C , C is opposite D). The children were then asked which coin or coins they would or would not take to the shop to buy as many sweets as possible. All children initially failed tests of derived responding and were subsequently exposed to extensive MET on the specific relations. After training, all children were able to demonstrate generalized opposite responding (including with novel coin sets as well as other stimuli such as pasta shapes).

Pérez-González, García-Asenjo, Williams and Carnerero (2007) used MET to attempt to establish derived antonyms. In this study, two children with pervasive developmental disorder were first tested for their ability to reverse intraverbal opposite pairs (e.g., if taught to respond “cold” in answer to the question “What is the opposite of hot?” could they answer the question “What is the opposite of

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cold?”). Both children failed these initial tests, but after specific training on the reversed relations with multiple sets of stimuli, both were able to demonstrate the reversed relations with novel stimulus sets. This can be seen as demonstrating derived symmetrical responding with antonyms. However, it is not clear that derived relational responding in a frame of opposition was demonstrated. At the level of mutual entailment, responding in accordance with opposite is symmetrical (if A is opposite B then B is opposite A) and is thus indistinguishable from sameness responding. It is not until combinatorial entailment is present (if A is opposite B and B is opposite C, then A and C are the same) that one could definitively identify this skill as relational responding within the frame of opposition. Moreover, in this study there was no test for the “meaning” of opposite relations, such as a test of transformation of function (e.g., as conducted in Y. Barnes-Holmes et al., 2004), or even of non-arbitrary “oppositeness”. One useful test of non-arbitrary opposite relations, for example, might involve allowing a child to feel three glasses of water at different temperatures - one cold, one hot and one neutral - and then allowing her to touch a further glass that is either hot or cold and asking her to put it first with the same and then with the opposite. If a child cannot pass tests that tap into relevant functions such as these then it is unlikely that they are responding to “hot” and “cold” as opposite in a meaningful way. As Pérez-González et al. (2007) did not test for any such functions then, from an RFT perspective at least, their results cannot be seen as a clear demonstration of opposite relations.

Teaching deictic frames. Perspective-taking skills have been shown to be crucial to a variety of social and interpersonal interactions (e.g., Baron-Cohen, 2001; Baron-Cohen, 2005; Flavell, 2004; Downs & Smith, 2004; Perner, 1988; Klin, Schultz, & Cohen, 2000; Perner, 1991). Traditionally this area of research has been the preserve of cognitive psychologists who explain perspective taking as being based on *Theory of mind* ability. Theory of mind (ToM) is said to involve being able to infer the full range of mental states (beliefs, desires, intentions, imagination, emotions, etc.) that cause action. In brief, having a theory of mind is to be able to reflect on the contents of one’s own and other’s minds (Baron-Cohen, 2001, p. 174). ToM theorists generally believe that perspective-taking skills emerge around 5 years

of age as a function of biological maturation (Baron-Cohen, 2005). However, from a current behavior analytic and more specifically RFT viewpoint, these skills are thought to emerge as a function of behavior-environment relations and as such can be targeted for intervention. For RFT, responding in accordance with perspective taking relations shares qualities of arbitrariness and generalization with other relations, but the interactions are more complex in the case of the former. RFT terms these *deictic* relational frames. Perspective taking involves three key types of relations: I versus you, here versus there, and now versus then. Responding in accordance with these relations is hypothesized to emerge in part through a history of responding to questions such as “What am I doing here?” or “What were you doing then?” Although the form of these questions is often identical across contexts, the physical environment is always different. What remain consistent are the relational properties of I versus you, here versus there, and now versus then. McHugh, Barnes-Holmes and Barnes-Holmes (2004) developed a protocol to examine these relational abilities. Specifically, the protocol looks at the three perspective-taking frames (I-you; here-there; now-then) across three levels of complexity (Simple, Reversed, and Double-Reversed). For example, children have to respond relationally to correctly answer questions such as, "I have a red ball and you have a blue ball, what ball do you have? What ball do I have? (simplest type of relation). A more complex scenario would involve a reversal (i.e., “If I were you and you were me, which ball would I have? Which ball would you have?”). Double-Reversed relations combine reversals of two deictic relations (e.g., “I am sitting here on a blue chair and you are sitting there on the black chair. If I was you and you were me and if here was there and there was here, where would I be sitting? Where would you be sitting?”). There is evidence that performance on these complex deictic relational responding tasks follows a similar developmental sequence to performance on tests of Theory of Mind (McHugh, et al., 2004; McHugh, L., Barnes-Holmes, Y., Barnes-Holmes, D., Stewart, I., & Dymond, S., 2007; Rehfeldt et al., 2007; Weil et al., 2011), and also that deictic relational performance correlates with intellectual functioning as measured by standardized IQ tests (Gore, Y. Barnes-Holmes & Murphy, 2010).

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Rehfeldt et al. (2007) demonstrated that specific multiple-exemplar training on simple, reversed, and double reversed relations for I-you, here-there, and now-then established these relational operants for two typically developing children (ages 9 and 10) when they were not present in initial testing. In a more recent study, Weil et al., (2011) replicated these findings in three younger children (57 to 68 months old). Using a shortened version of the perspective-taking protocol (McHugh et al., 2004) and using a multiple baseline design across persons and tasks, deictic relational frames were successfully trained. All three children showed clear increases in deictic framing that generalized across stimuli, suggesting the acquisition of an operant class. In addition, all of the children showed improvement on Theory of Mind tasks following improvements in deictic performance at the Reversed and Double-Reversed levels. This research, while only beginning, is particularly exciting as it indicates the possibility of teaching perspective taking to children with ASD, for whom it appears to be a key deficit.

Teaching Using an Existing Repertoire of Derived Relational Responding

Studies that have used participants' existing repertoire of derived relational responding to further other educational goals will next be examined. That is, these studies have not employed MET to *establish* the ability to derive relations as such, when that skill is absent (as described above). Rather, they have employed relevant stimulus arrangements within match-to-sample procedures to train specific conditional discriminations and thereby capitalize on the derived responses that would be seen when an individual already has a repertoire of derived relational responding. In these studies, participants were (either immediately or after a limited amount of testing) able to respond accurately on tests of emergent relations (for example, by demonstrating stimulus equivalence, or by passing a test of combinatorial entailment within a frame of comparison), thus indicating that the relevant relational responding skills had already been acquired. A key feature of these studies is that they involve the training of a limited selection of relational responses (e.g. A-B and C-B), followed by testing for additional derived relations (e.g., A-C). Successful demonstrations illustrate the potential generative power of

such training arrangements (which will be referred to as using an “equivalence training/testing procedure”) for those with a suitable repertoire.

The studies described in this section represent that sample of the available literature that has focused on teaching educationally-relevant skills to individuals with ASD or other developmental delays (for reviews of studies that include other populations and/or are experimental rather than applied in nature, see May, Hawkins & Dymond, 2013; McLay, 2013; Rehfeldt, 2011). Skills targeted for improvement have included reading and spelling (e.g., De Rose, de Souza, & Hanna, 1996; Sidman, Cresson, & Willson-Morris, 1974); name-face matching (e.g., Cowley, Green, & Braunling-McMorrow, 1992); transitioning using activity schedules (Miguel et al., 2009; Sprinkle & Miguel, 2013); US geography (LeBlanc, Miguel, Cummings, Goldsmith & Carr, 2003); money skills (Keintz, Miguel, Kao & Finn, 2011; McDonagh, McIlvane & Stoddard, 1984); communication skills including manding using manual signs, picture exchange communication and vocal communication (e.g., Gatch & Osborne, 1989; Halvey & Rehfeldt 2005; Murphy & Barnes-Holmes, 2009a, 2009b; Rehfeldt & Root, 2005; Rosales & Rehfeldt 2007); and using metaphorical reasoning (Persicke et al., 2012).

Teaching skills using simple derived relational responding. The basic match-to-sample method used by Sidman (1971) has been employed in several studies to capitalize on the emergence of derived relations between pictures and text. De Rose et al. (1996) used this method to teach reading and spelling to typically developing children who were nonreaders and behind their peers. The students learned to match 51 printed words to the corresponding dictated words and to copy and name printed words with movable letters. All of the children showed the emergence of reading skills, and some also read generalization words at the conclusion of training. Similarly, Cowley et al. (1992) taught adults with brain injuries to conditionally relate their therapists’ dictated names to their photographs and written names. Posttests showed the emergence of untrained conditional relations involving photos and written names, and 2 participants were capable of orally naming the photos. Sprinkle and Miguel (2013) and Miguel et al. (2009) evaluated whether an appropriate pattern of conditional discrimination training

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would serve to transfer the control from activity-schedule pictures to printed words (i.e., derived textual control). In these studies, preschoolers with ASD were taught to select pictures and printed words given their dictated names. Following training, participants could respond to printed words by completing the depicted task on an activity schedule, match printed words to pictures, and read printed words without explicit training (i.e., they showed emergent relations, including transfer of function). Sprinkle and Miguel (2013) further found that training of conditional discriminations using matching to sample protocols was superior to stimulus fading procedures for facilitating the demonstration of emergent relations.

Other academic skills have also been targeted using equivalence training/testing procedures. LeBlanc et al. (2003) taught US geography facts to two children with ASD, using a match-to-sample procedure. Both children were able to master the trained geography relations and emergent stimulus relations were also observed. Keintz et al., (2011) examined the applicability of stimulus equivalence to teaching money skills to children with ASD. The participants were taught three relations between coins, their names, and values. After the initial training, four relations emerged for the first participant and seven for the second, suggesting that this technology can be incorporated into educational curricula for teaching prerequisite money skills to children with ASD.

A number of recent studies have also extended functional communication by capitalizing on relational responding skills. Rehfeldt and Root (2005) examined whether training in specific conditional discriminations would result in derived manding skills in three adults with disabilities (in fact this was the first empirical demonstration of this phenomenon). Participants were first taught to mand for preferred items using pictures; they were then taught conditional discriminations between pictures and their dictated names and between dictated names and their corresponding text. Manding for preferred items using corresponding text was then evaluated and all three participants demonstrated derived manding. In another study, Halvey and Rehfeldt (2005) demonstrated derived vocal manding in three adults with severe developmental disabilities. Again, they evaluated whether a history of training in specific conditional discriminations would give rise to untrained vocal

manding for novel items. Participants were first taught to mand for preferred items using their category names. They were then taught conditional discriminations between pictures of preferred items that were categorically related. Finally, they were tested with respect to manding for items that had not been originally presented during mand training, using their category names. All participants demonstrated untrained manding, and for some of them, changes in the mand repertoire were accompanied by changes in the tact repertoire. Some participants also showed generalization of skills across settings.

Murphy and Barnes-Holmes (2009a) also established more complex derived manding with individuals with ASD, showing the transfer of functions of “more” and “less” in a token game (similar to that described previously). Participants were first taught to mand for either “more” or “less” tokens using arbitrary symbols (A1 and A2). Following training in the relevant conditional discriminations (A-B and C-B), participants were then able to mand for either “more” or “less” tokens using the newly-related symbols (C1 and C2). Extending this work, Murphy and D. Barnes-Holmes (2009b) taught specific mands for +2, +1, 0, -1, and -2 tokens (A1, A2, A3, A4, and A5) in a similar game. Following training in the relevant baseline conditional discriminations (A-B and B-C), participants then demonstrated derived manding using the newly related symbols (C1, C2, C3, C4, and C5).

The vast majority of studies teaching educationally-relevant skills using existing derived relational responding repertoires have utilized participants’ skills within a frame of coordination or stimulus equivalence. As described previously, though, RFT proposes numerous other relational frames, and existing skills in any frame could potentially be used to teach other skills more efficiently. For example, in Murphy and Barnes-Holmes (2010), responding within a frame of comparison was established, and five of the seven participants then demonstrated derived manding via transformation of functions within the frame of comparison, in the context of the token game.

Teaching skills using complex derived relational responding. One particularly interesting and potentially useful example of a relational framing skill is that of relating relations themselves, which is the basis of analogical and

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metaphorical reasoning. Like perspective-taking, analogical reasoning is a complex verbal repertoire and has traditionally been investigated from a cognitive perspective. In this view, deficits in metaphorical language seen in children with ASD and other developmental delay are thought to be caused by dysfunction in underlying neurolinguistic mechanisms (e.g., Baron-Cohen, 2001; Gold & Faust, 2010). Relational frame theorists (e.g., Barnes, Hegarty & Smeets, 1997; Stewart & Barnes-Homes, 2001a; 2001b) have provided an interpretation of this repertoire based on relating derived relations in the context of a variety of different types of relations. In a classic analogy test, two different stimulus sets should be related if they each show the same type of relation—e.g., apple is to fruit as cat is to mammal (each set demonstrating a hierarchical relation), nickel is to dime as apartment is to mansion (each set demonstrating a comparison relation), etc. As such, analogy has been examined by behavior analysts as the relating of derived (and typically equivalence) relations. For example, in the first published study of this effect, Barnes, Hegarty and Smeets (1997) first trained and tested participants for equivalence relations amongst arbitrary stimuli and subsequently showed that they would also relate pairs of stimuli in equivalence relations to each other and pairs of stimuli in non-equivalence relations to each other. For instance, after first deriving the equivalence relations A1-B1-C1, A2-B2-C2, A3-B3-C3 and A4-B4-C4, participants subsequently matched B1-C1 (equivalent) to B3-C3 (equivalent) rather than B3-C4 (non-equivalent), and matched B1-C2 (non-equivalent) to B3C4 (non-equivalent) rather than B4C4 (equivalent).

Barnes et al. (1997) and the other studies just cited generally used adults or older children to show the equivalence-equivalence effect. However, in more recent studies of greater relevance to the current review, Carpentier, Smeets and Barnes-Holmes (2002, 2003) tested relatively young developmentally typical (5 year old) children and showed both that they were not able to consistently demonstrate equivalence-equivalence relations (in contrast with 9 year olds and adults, thus indicating a developmental pattern similar to that shown in classic analogy research) as well as that with suitable training they could be supported in the derivation of these relations. Carpentier et al. suggest that the learning of this skill happens to a

significant extent based on training that children receive in typical academic environments. Their research points in important directions as regards the testing and training of this potentially important repertoire in both typically developing and developmentally delayed populations.

From an RFT point of view, metaphor is similar to analogy in that it also involves deriving relations of sameness between relational networks. In addition, in metaphor, a key part of the process is identification of a property shared between the two related domains which supports the derivation of relational similarity. In a recent study, Persicke et al. (2012) evaluated multiple exemplar training for teaching children to attend to relevant features of the context in which a metaphor was used and to engage in the required relational responding in order to respond correctly to metaphorical questions. In this case, the component relational responding skills (coordination, distinction, and hierarchy) were already established, but, in accordance with an RFT approach, the children were taught using MET to use these existing skills in combination. Three children, aged 5–7 years with a diagnosis of ASD participated. For each trial the experimenter read a story (e.g., “One of my co-workers brought a cake to work last week. The cake had fluffy frosting, and it smelled really good, but the cake was really hard on the inside”) and asked questions based on a metaphor (e.g., “If I say the cake was perfume, what do I mean?”) that required the identification of the property in common between the target and vehicle (e.g., smelling good). While the specific content of the stories and metaphors changed across trials the relations targeted remained constant and the results suggested that MET was effective for remediating deficits in metaphorical reasoning. All participants demonstrated generalization of this pattern of responding to multiple untrained metaphors and it was anecdotally reported that some children started to create their own metaphors across the intervention (i.e., expressive untrained metaphorical language skills were also emerging). The potential to teach such a flexible, generally applicable skill, as opposed to teaching a child to memorize particular content (i.e., learning metaphors rotely) further supports the merits of targeting skills using an RFT analysis when designing language interventions for children with ASD or developmental delay more broadly.

Conclusions and Directions for Research

As outlined above, there is now a small but growing body of evidence both for using existing derived relational responding repertoires to quickly and efficiently teach new concepts and generate more varied responding (such as novel mands), and also for training repertoires relevant to derived relational responding when they are absent. As stated initially, RFT offers both clear empirical evidence as well as a clear conceptual pathway for identifying both priorities for skills to teach (i.e., flexible derived relational responding repertoires across a variety of relational frames) as well as procedures for teaching such skills, and will be used as the foundation for the work in the remainder of this thesis. Nonetheless, regardless of the differences in theoretical orientations and debate within the field about underlying processes, all the studies reviewed in this chapter have in common the fact that they point to environmental histories/manipulations that result in “generative” verbal behavior. The implications for teaching language to individuals with ASD or developmental disabilities (as well as providing suggestions for more efficient and effective educational strategies in general) are significant.

First, if a student can demonstrate derived relational responding of a particular type (e.g. equivalence, naming, comparison), then those skills may be used to more efficiently program lessons for learning new vocabulary and academic skills, and for rapidly expanding functional communication skills. Moreover, knowing that a student is able to demonstrate particular relational skills is one indicator of when to stop specifically targeting particular skills—for example, if a student is able to demonstrate equivalence, it is likely not necessary to continue targeting specific nouns, verbs, and so on for teaching both as a listener discrimination and as a tact. It could be argued that derived relational skills such as this are a more critical progress marker than simply the quantity of listener discriminations or tacts that a student has learned.

Second, if a student cannot demonstrate particular derived relational responding repertoires (whether naming, equivalence, or more advanced relational frames), then it can be argued that curricular programming should focus on establishing those skills through multiple exemplar training of the relevant pattern of

responding. Luciano et al. (2009) make a number of suggestions for training early relational operants based on RFT, and the research in this thesis includes a focus on exploring such training. Some of the research studies that have been discussed in this chapter also give some indications of important teaching and curricular sequencing principles, as follows:

- 1) multiple exemplar training in bidirectional stimulus relations would appear to be critically important for establishing mutual entailment (Luciano et al., 2007; Pérez-González et al., 2007) and naming (Greer & Ross, 2008);
- 2) multiple exemplar training can also be used to facilitate the emergence of combinatorially entailed derived relational responding in a number of frames (Berens & Hayes, 2007; Gorham et al., 2009; Barnes-Holmes et al., 2004), as will be explored further in Chapter 6;
- 3) training transfer of mand functions may be an efficient as well as functionally important method of facilitating the emergence of equivalence as well as other frames (Murphy et al., 2005; Murphy & Barnes-Holmes, 2010), and training transformation of function will be further explored in Chapter 8;
- 4) ensuring fluent non-arbitrary relational responding within a particular frame is almost certainly necessary prior to attempting to teach arbitrary relational responding (Barnes-Holmes et al., 2004; Berens & Hayes, 2007; Gorham et al., 2009), as will be discussed further in Chapters 8 and 9;
- 5) perspective-taking—a critical deficit for children with ASD—may be facilitated through the use of procedures for training deictic relational framing (McHugh et al., 2004; Rehfeldt et al., 2007; Weil et al., 2011);
- 6) multiple exemplar training that targets a number of arbitrary relational frames can effectively establish flexible, generally applicable skills in metaphorical reasoning that have previously been shown to be deficient (Persicke et al., 2012).

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Finally, in order to implement the above recommendations, it is first necessary to assess a student's current derived relational responding repertoire, as this will inform the development of goals and curricula. This is not as yet a typical component of assessment in intervention programs for children with ASD (although some assessment tools such as the Verbal Behavior Milestones Assessment and Placement Program [Sundberg, 2008b] do reference the emergence of novel behavior as a progress marker, as has been previously noted), and it can be argued that it should be. A critical area for future research is the development of a standardized tool for the systematic assessment of relational responding abilities and their precursor skills. One such tool, the Training and Assessment of Relational Precursors and Abilities (TARPA; Moran, Stewart, McElwee & Ming, 2010; Moran, Stewart, McElwee & Ming, 2014), was utilized and further developed as part of the current line of research, as will be discussed in the next chapter.

Rehfeldt (2010, 2011) has highlighted a number of additional research priorities which have also helped to shape the focus of this thesis. In an analysis of articles in the *Journal of Applied Behavior Analysis* on the topic of derived stimulus relations, Rehfeldt (2011) noted the relative dearth of research looking at relational responding with respect to auditory stimuli and considered this noteworthy given how fundamental the formation of auditory-visual stimulus relations is with respect to understanding spoken language. The current line of research has thus focused on derived relational responding involving natural language contexts and the assessment and training of auditory-auditory relations as well as auditory-visual relations. As will be discussed further in the next chapters, these can also be conceptualized as derived intraverbal and derived tact/listener relations. By taking such an approach, the current line of research also attempts to further the synthesis of RFT and Skinnerian verbal behavior approaches, as recommended by Rehfeldt (2010).

A move away from the match-to-sample formats frequently used in research into relational responding may also be necessary in order to develop a better applied technology, as the verbal community more often requires topography-based responding rather than selection-based (Rehfeldt, 2011). In addition, Rehfeldt outlined the need for research that included examining the transportability,

generalization and maintenance of relational responding interventions. In the current line of research, both selection-based as well as topographical response forms were examined. This included the generalization of selection-based responding from computer-based to tabletop activities (Chapters 6 and 8), as well as development and testing of tabletop protocols themselves (Chapter 9), and testing for maintenance of the trained and generalized skills (Chapter 9).

Rehfeldt (2011) further outlined the need for researchers to look beyond equivalence responding if the derived stimulus relations paradigm is to have any utility in teaching more complex skills. The current line of research extends work presented in the preceding review in this chapter, by focusing not only on derived relational responding within frames of coordination (Chapters 5 and 6), but also distinction (Chapter 8), and relational responding relevant to frames of hierarchy (Chapter 9). Studies in this line of research have also considered the applicability of particular patterns of relational responding to more complex, academically relevant skills such as reading comprehension (Chapter 8) and categorization (Chapter 9).

Rehfeldt (2010) highlighted the need for translational studies on derived relational responding. The current work has included modifications of the types of procedures that have been used in basic research, for testing in applied settings with an emphasis on the development of immediately applicable procedures for teaching children with autism. Consequently, in addition to its primary aim of addressing some of the identified critical research needs within the field, the research presented in this thesis has significant practical relevance. One result has been the provision of evidence-based protocols for training derived relational responding using natural contexts for language development, and focusing on skills that are critical for conversation . This will be of immediate practical benefit for informing curricular programming for ABA-based intervention programs for children with autism. The development of a repertoire of generative language skills should allow a child to make major gains educationally and socially, and thus, the programs developed for this research, as presented in the chapters to follow, should be a key addition to already existing tools for early intensive behavioral intervention.

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Chapter 4:
Assessing and Training Frames of Coordination

Frames of Coordination

The first frame examined in the current line of research was that of coordination—the pattern of derived relational responding (DRR) that characterizes the classic pattern of stimulus equivalence in which stimuli are “substitutable” for one another. Establishing appropriate frames of coordination among auditory and visual stimuli is clearly critical for language development, and thus the current line of research included this as a key aim. More specifically, it targeted frames of coordination among two auditory and one visual stimulus. This particular pattern was chosen because the responses involved can be viewed from the perspective of a Skinnerian analysis of verbal behavior as including two of the primary verbal operants—tacts and intraverbals—as well as listener behavior (see Figure 4.1)¹. Particularly from the perspective of working with early language learners, combining a Skinnerian verbal behavior approach with Relational Frame Theory (RFT; Hayes, Barnes-Holmes & Roche, 2001) would seem to have considerable merit, in part by bringing together the work on how to best *teach* early verbal operant responses (as briefly discussed in Chapter 2) with the literature on *deriving* relations. D. Barnes-Holmes, Y. Barnes-Holmes and Cullinan (2001) suggest that the Skinnerian verbal operants—mands, echoics, textual behavior, transcription, tacts, intraverbals and autoclitics—may be classified into two forms of each operant, either based on direct contingency training (i.e., taught) or based on contextually controlled arbitrarily applicable derived relational responding (which, for the sake of simplicity, will be referred to in the context of a specific verbal operant as simply “derived”) (see Figure 4.1). This is the perspective that is taken in describing the relevant relations in

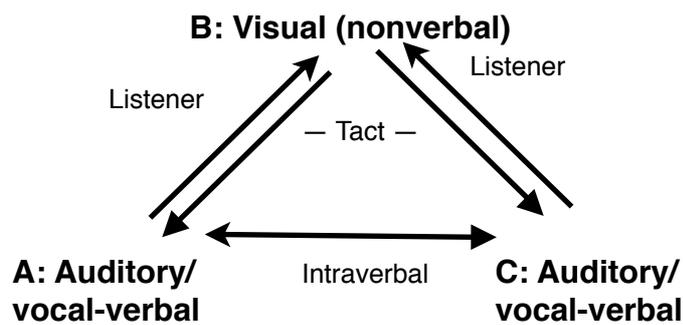
1. From the perspective of Skinner’s (1957) analysis of verbal behavior, so long as the auditory/vocal stimuli involved meet that definition of being “verbal” (i.e. reinforced through the mediation of a member of the verbal community), then the visual-auditory relation could be classified as a tact, and the auditory-auditory relation could be classified as an intraverbal. It should be noted, however, that RFT would not define a response as “verbal” unless it demonstrates *contextually-controlled arbitrarily applicable derived relational responding*.

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the work in the next two chapters on assessing and teaching DRR in frames of coordination.

A number of studies have investigated the use of derived relational responding paradigms synthesized with Skinner’s (1957) analysis of verbal behavior (e.g., Rosales & Rehfeldt, 2005; Murphy, Barnes-Holmes & Barnes-Holmes, 2005). In addition, as reviewed in the previous chapter, a number of studies working from a variety of theoretical perspectives have used multiple exemplar training (MET) to train coordinate relations with auditory and visual stimuli—that is, derived tact and derived intraverbal responding.

Relations among stimuli as taught verbal operants:



Relations among stimuli as taught and derived verbal operants:

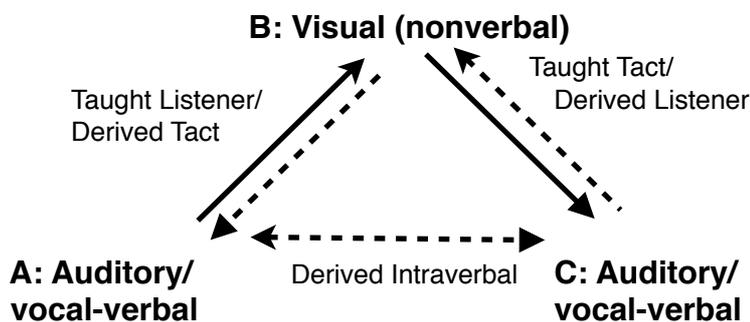


Figure 4.1. Relations among visual and auditory stimuli from the perspective of Skinner’s (1957) analysis of verbal behavior.

Several studies (Fiorile & Greer, 2007; Greer, Stolfi, Chavez-Brown & Rivera-Valdes, 2005; Greer, Stolfi & Pistoljevic, 2007) working from a naming perspective have demonstrated the effectiveness of MET for facilitating derived relations between auditory and visual stimuli. As noted in Chapter 3, from an RFT perspective, naming can be viewed as an example of mutually entailed name-object relations. Naming can also be conceptualized as an example of derived tacting (i.e., deriving the tact response having been taught a listener response). Also at the level of mutually entailed relations, two studies have used MET for facilitating auditory-auditory derived relations—termed “reverse intraverbals” (Pérez-González, Garcia-Asenjo, Williams, & Carnerero, 2007; Allan, Vladescu, Kisamore, Reeve & Sidener, 2014). It should be noted that in these studies, almost all participants were at relatively advanced levels of language development (approximate age equivalencies of 6 years old or higher) and so it seems likely that the participants already had at least some repertoire of mutual entailment. In any event, the MET intervention in the study by Pérez-González et al. (2007) was successful for the one participant who could be considered at an early stage of language development (age equivalency of 2.92 on the Peabody Picture Vocabulary Test [PPVT]). However, the MET intervention in the study by Allan et al. (2014) was not successful for the one participant in that study who was at a similarly early stage of language development (Level 2 on the VB-MAPP).

With respect to combinatorially entailed relations, Walsh, Horgan, May, Dymond and Whelan (2014) (as discussed in Chapter 3) required some participants to derive relations at the combinatorial entailment level between two textual stimuli following training in text-picture relations (i.e. B and C stimuli were text while A was a picture), while others were required to derive relations with all stimuli being textual. In both of these cases, the responses may be conceptualized as derived intraverbal responding using text. While all participants in this study did have language delays, two of the three participants who completed the MET intervention could be considered at a relatively advanced level of language skill (within the low average range for 5 and 6 year olds, based on percentile scores). Although they did require a few sessions of MET prior to demonstrating the derived responses with

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novel textual stimuli, it seems possible that they may have had at least an early emergent repertoire of DRR (e.g. with other stimulus modalities) given their developmental language level.

Thus, there is evidence that multiple exemplar training in relational framing in a pattern of coordination is effective at the mutual entailment level with tact/listener discriminations and intraverbal responding, and there is some evidence at the combinatorial entailment level with intraverbal responding using textual stimuli. However, prior to the current work, there had as yet been no research on establishing combinatorially entailed derived intraverbals using what would seem to be the key modality seen in typical early language development: that is, between vocal/auditory stimuli. Furthermore, there is very limited research on establishing coordinate framing with individuals at an early developmental level of language skills. The current line of research thus extends the existing work on early emergent DRR by specifically examining the assessment and training of a pattern of coordinate framing involving training tact/listener responses (and testing for mutual entailment) and deriving combinatorially entailed intraverbals with auditory/vocal stimuli. The research specifically examined such responding by individuals who have no existing repertoires of DRR, or for whom any repertoire could be considered limited and fragile—that is, individuals for whom any potential repertoire of DRR was not well-established with respect to consistency and fluency of responding, nor well-generalized across settings, contexts, stimuli and so on. As such, it represents the first exploration of the effectiveness of MET in this critical language pattern with this population using both auditory and visual stimuli.

The Training and Assessment of Relational Precursors and Abilities

As discussed briefly in the previous chapter, before setting out to train children with autism in derived relational responding, it is first necessary to assess their current repertoire of DRR. The current research utilized the Training and Assessment of Relational Precursors and Abilities (TARPA; Moran, Stewart, McElwee & Ming, 2010, 2014; Moran, Walsh, Stewart, McElwee & Ming, 2015) to first assess and then train precursor and early relational responding abilities. The

TARPA is a computer-based protocol (presented on an iPad throughout the current research) that assesses a number of key forms of responding, including both prerequisites to DRR as well as aspects of DRR itself—namely, basic discrimination, non-arbitrary conditional discrimination, arbitrary conditional discrimination, mutually entailed relational responding, combinatorially entailed relational responding and transformation of function. In addition, sections are further divided into tracks based on the modality of the stimuli involved (e.g., visual only, auditory only or a combination of both visual and auditory stimuli). Thus, the TARPA provides a useful assessment of arguably some key prerequisite skills to relational responding as well as of relational responding abilities in frames of coordination.

As an assessment tool, the TARPA (both in its full form and in a modified form testing only one of the stimulus modality tracks) has been shown to have strong and significant correlations with the Vineland Adaptive Behavior Scales (Moran et al., 2010), the Preschool Language Scale 4th edition (Moran et al., 2014, 2015), and the Stanford-Binet 5th edition (Moran et al., 2015). Patterns of responding on the TARPA thus support the interpretation that DRR plays a critical role in the behavioral repertoires commonly referred to as language and cognition.

The exploration of early emergent DRR repertoires in this thesis also entailed the development of the training components of the TARPA and determining whether skills learned through the iPad-delivered activities might generalize to the domain of more common language activities. In developing these aspects of the TARPA within the current program, the full gamut of all modalities and skills included in the TARPA was not employed. Nevertheless, the full structure of the TARPA program is presented here as background, given that a number of the published studies cited in this thesis, which preceded the current work, involved the full implementation of the protocol. For the *SAME* (i.e., coordination) relation the TARPA involves three *stages*, as follows:

1. Basic discrimination
2. Conditional discrimination (formally SIMILAR stimuli)
3. Conditional discrimination (formally DISSIMILAR stimuli)

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Each stage is further subdivided into *tracks* corresponding to different modalities tested (visual-visual, auditory-visual-visual, auditory-visual-auditory, or auditory-auditory). Parenthetically, in the current research, only the auditory-visual-auditory (“AV2”) track was employed. Each track in Stage 3 is further subdivided into levels, as follows:

1. Conditional discrimination
2. Mutual entailment
3. Combinatorial entailment
4. Transformation of function

Levels 2 through 4 have additional sub-sections as detailed in Figure 4.2. For each stage, levels and sections may be categorized as (a) *directly trained*, in which specific discriminations are taught, (b) *maintenance tests*, in which discriminations are tested in the absence of reinforcement provided by the program, (c) *tested*, in which the child is assessed for generalization, derived relations or transformation of function, or (d) *relational training*, in which the student is trained to respond in accordance with the derived relations.

The primary aim of the current research with respect to frames of coordination was to explore the assessment and training of DRR when working with very early learners who may have no, or very limited, abilities to derive responses. This research was undertaken with a view to identifying variables that might make DRR more or less likely, and to preparing a protocol that might be used to establish an initial repertoire of DRR. Because the TARPA assesses a wide range of skills relevant to coordinate framing, it was used as the primary assessment and training tool for this research, and was modified and developed further as the needs of each study required, as will be described further in subsequent chapters. Early (unpublished) pilot work (Ming, Stewart, Moran & McElwee, 2011; Stewart, McElwee, Ming & Burgess, 2010) also led to a more systematic investigation of some of the variables that may potentially impact the demonstration of DRR when such repertoires are fragile. These variables will be discussed next.

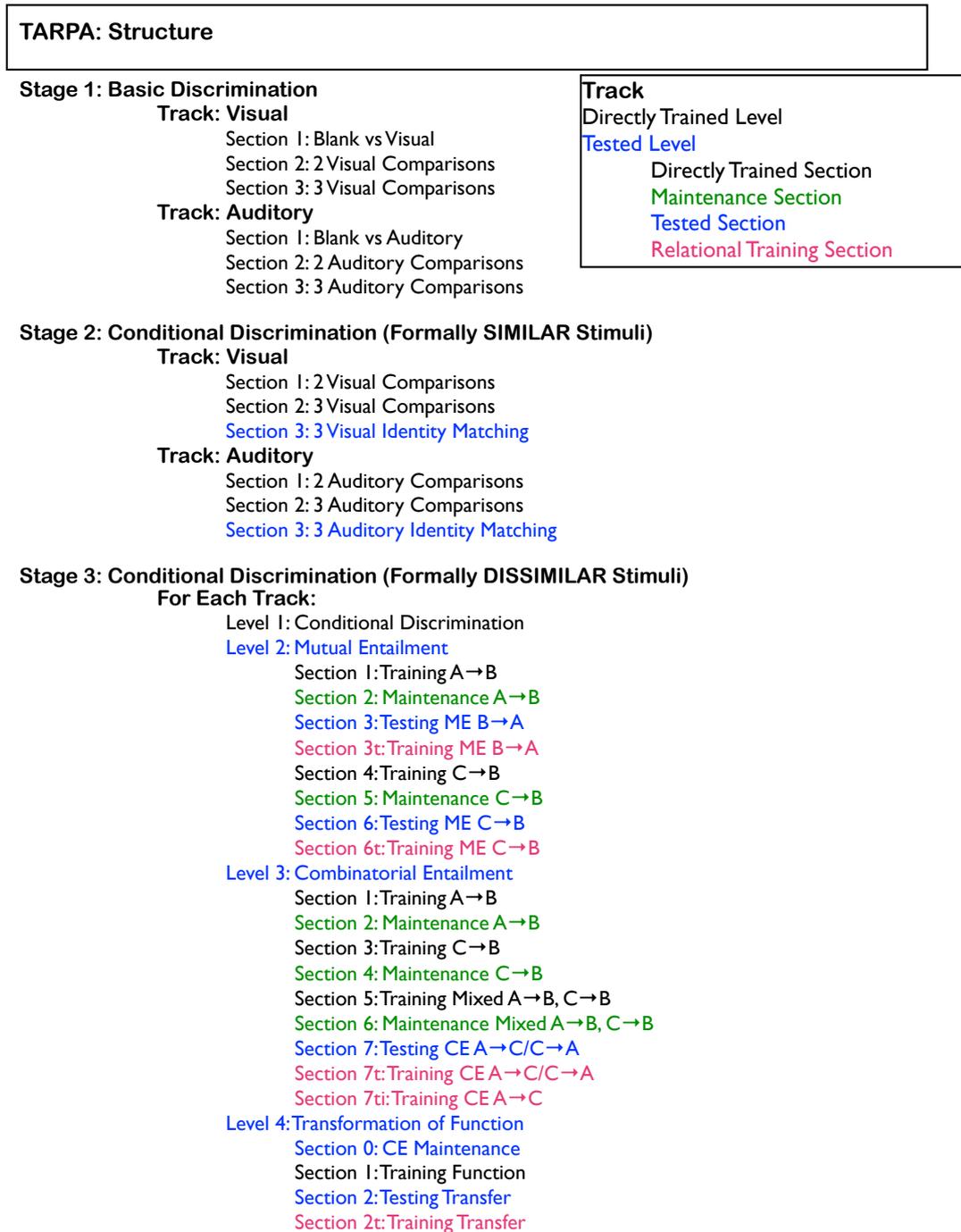


Figure 4.2. Overall structure of the *Training and Assessment of Relational Precursors and Abilities* (TARPA).

Variables Affecting the Demonstration of DRR

In early pilot testing (Ming, et al., 2011; Stewart, et al., 2010), many children with autism who were clearly able to rapidly learn tact, listener and intraverbal responses during typical educational activities had great difficulty with the testing conditions as used in the standard TARPA administration, sometimes even failing to either acquire baseline relations or to maintain them under unreinforced conditions. Pilgrim, Jackson and Galizio (2000) similarly note that even typically developing young children may fail to easily acquire arbitrary conditional discriminations in the absence of a familiar verbal context, despite clearly being able to acquire conditional discriminations in the course of their natural language learning. Thus, further investigation seemed necessary to provide alternatives to the standard TARPA administration that might better capture the potentially fragile DRR repertoires of this population, while ensuring a valid and reliable means of determining the most complete picture of students' relational responding skills, particularly with respect to derived tact, listener, and intraverbal responding. Research over the last several decades has shown that demonstration of derived relational responding may be more likely given a number of factors. This literature informed a number of decisions in terms of the protocols for administration of the TARPA as used in the current research on training DRR, as well as the further exploration of the effects of these variables during assessment.

Elements of the TARPA that may support DRR

Auditory-visual stimuli. One of the factors that makes demonstration of DRR more likely is using both auditory and visual stimuli, as opposed to visual alone: Smeets and Barnes-Holmes (2010) found that, consistent with earlier research (Green, 1990), children were more readily able to demonstrate stimulus equivalence when match to sample training included an auditory stimulus as well as visual stimuli. In the current line of research, the use of both auditory and visual stimuli should therefore make the demonstration of derived relational responding more likely .

Task-relevant instruction. The use of task-relevant instructions also makes the demonstration of derived relational responding more likely, at least in part because it makes it more likely for individuals to acquire the necessary arbitrary conditional discriminations in baseline training, compared to the use of differential reinforcement procedures alone (Arntzen, Vaidya, & Halstadro, 2008; Pilgrim, Jackson & Galizio, 2000). In the TARPA, explicit instruction is given during conditional discrimination training, and this should also support the acquisition of the baseline conditional discriminations and subsequent demonstration of derived relational responding.

Type of training design. Another potentially important variable is the type of training design used for establishing baseline conditional discriminations. There is evidence that this can affect both the speed of acquisition of the discriminations as well as the likelihood of derived relational responding being demonstrated. “Many-to-one”, also known as “comparison as node” baseline training designs have often been found to more readily produce responding in accordance with stimulus equivalence than “one-to-many” (“sample as node”) designs (Saunders, Wachter & Spradlin, 1988; Spradlin & Saunders, 1986; Barnes, 1992 as cited in Barnes, 1994; Arntzen & Vaidya, 2008). Barnes (1994) suggests that this effect may be due to the greater transfer of respondent stimulus functions which may produce contextual cues for responding in accordance with a frame of coordination, and/or a greater number of discriminative functions established during many-to-one training designs. However, Arntzen and Holth (2012) found the opposite pattern to what had been seen in earlier studies, including those cited above: in their study, a one-to-many design resulted in superior training and testing performances. In another study that showed results in conflict with previous work, and also different from what Arntzen and Holth found subsequently, Smeets and Barnes (2005) found no difference in performances using one-to-many vs many-to-one training.

Since the current line of research investigates derived intraverbal responding following tact/listener training, the training design chosen also determines whether baseline relations are trained as tact or listener responses: given two auditory stimuli (A and C) and one visual stimulus (B), a many-to-one training design would involve

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training listener responses (A-B, C-B), and deriving mutually entailed tact (B-A, B-C) responses and combinatorially entailed intraverbal (A-C) responses. A one-to-many training design would involve training tact (B-A, B-C) responses, and deriving mutually entailed listener (A-B, C-B) responses and combinatorially entailed intraverbal (A-C) responses. This issue complicates the picture of what training design to use. In general, it has been shown that at the mutual entailment level, training tact responses is more likely to result in derived listener responses than vice versa (see Petursdottir & Carr, 2011 for a review of this research). At the combinatorial entailment level, there is some evidence for tact training being slightly more likely than listener training to result in derived intraverbal responding (Petursdottir, Olafsdottir & Aradottir, 2008; Sprinkle & Miguel, 2012) while also evidence that tact training is not necessary for the emergence of equivalence relations (McLay, Church & Sutherland, 2014).

In the current line of research, both many-to-one training designs (training listener responses and deriving tact and intraverbal responses) and one-to-many training designs (training tact and deriving listener and intraverbal responses) were used, as will be described in the next chapters. Participants were screened on both formats to ensure they were not able to already demonstrate combinatorial entailment with any training format. In both training formats, testing was conducted to ensure mutually entailed responding prior to the combinatorial entailment test. Thus, regardless of which training format was used, participants would emit both tact and listener responses in baseline relation training/testing, addressing any potential facilitative effect of tacting as well as providing the additional support of mutual entailment testing (which has itself been shown to facilitate derived responding [Adams, Fields & Verhave, 1993; Fields, Adams, Newman & Verhave, 1992; Smeets, Dymond & Barnes-Holmes, 2000]).

Number of trained relations. The number of individual trained relations can also be important. This is a function of how many equivalence relations (e.g., A1-B1-C1 and A2-B2-C2 are two separate three-member relations) are trained as well as how many members each relation contains (e.g., A1-B1-C1 has three members while A2-B2-C2-D2 has four members). The more individual trained relations involved,

the more conditional discrimination training is necessary and there is evidence that the number of trained relations can affect both the ease of acquisition of conditional discriminations and the likelihood of subsequently demonstrating derived responding (Arntzen & Hansen, 2011; Arntzen & Holth, 2000). It has also been argued, however, that more than two comparisons must be used for a valid test of equivalence (Sidman, 1987; Carrigan & Sidman, 1992), (which, given the rationale and format of traditional MTS, would thus require establishing at least three equivalence relations); among other possible issues, using a reduced number of trained relations increases the possibility of passing tests on the basis of chance guesses and then maintenance of consistent responding. Nonetheless, Boelens (2002) has argued that the technical drawbacks of using a two comparison test can be relatively easily overcome by procedures such as including multiple derivation tests and stringent criteria for all derivation tests. Moreover, Pelaez, Gewirtz, Sanchez and Mahabir (2000) suggest that very young children may not easily be able to learn or remember more than two conditional discrimination relations before being tested for equivalence, and suggest that the complexity of the conditional discrimination task requirements may have been a factor in other studies in which participants have failed to pass tests of derived relational responding. Many participants in the earlier pilot tests also had great difficulty with acquiring and maintaining new relations between abstract stimuli with three comparisons. Given all of these factors, in the current research it was decided to focus on training and testing of two, 3-member classes (i.e., A1-B1-C1 and A2-B2-C2), while using stringent pass criteria.

Variables impacting DRR explored in the current research

In addition to the variables considered above with respect to the protocols used with the TARPA in the current work, two other factors were considered and further investigated in the studies in Chapters 5 and 6: the instructional context of the task and the type of stimuli used.

Context and DRR. RFT proposes that it is the naturally occurring multiple exemplar training present in children's early learning environments that leads to the development of derived relational responding. A number of factors facilitating the

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demonstration of derived relational responding are also seen in children's natural language learning environment: that is, auditory stimuli are naturally present as caregivers interact verbally with children; familiar, nameable, pronounceable, and "meaningful" stimuli are repeatedly encountered; and caregivers naturally make their expectations and instructions clear. It stands to reason that the first emergence of derived relational responding would be seen under such circumstances during assessment as well, and thus it was determined that a more natural context for testing and training was desirable for training these very early skills when they appeared to be absent.

One context that might be particularly effective for exploring early emergent coordinate DRR, and which had not been previously tested, is the game of linking animals with both their names and the sounds they make (see Figure 4.3). This context is the basis of many children's songs, games, iPhone apps, and common activities in preschool/toddler programs. It is recommended for toddler language development (American Speech-Language-Hearing Association, 2012), and it is common in early intensive behavioral intervention (EIBI) programs. Indeed, learning animal names and sounds may be among the first opportunities that children have to develop derived equivalence responding. In fact, consistent with this suggestion, Lipkens, Hayes and Hayes (1993) successfully used this context to chart the emergence of DRR including both mutually and combinatorially entailed derived relations in a very young typically developing child.

It was suspected that participants might be considerably more likely to demonstrate a repertoire of DRR, even if it were fragile, in the context of a "game" about animals and the sounds they make, and that this context might also be very supportive when establishing an early repertoire of DRR. This possibility was further explored in the initial assessment studies (presented in Chapter 5), and was used in the studies that followed on training DRR (presented in Chapter 6).

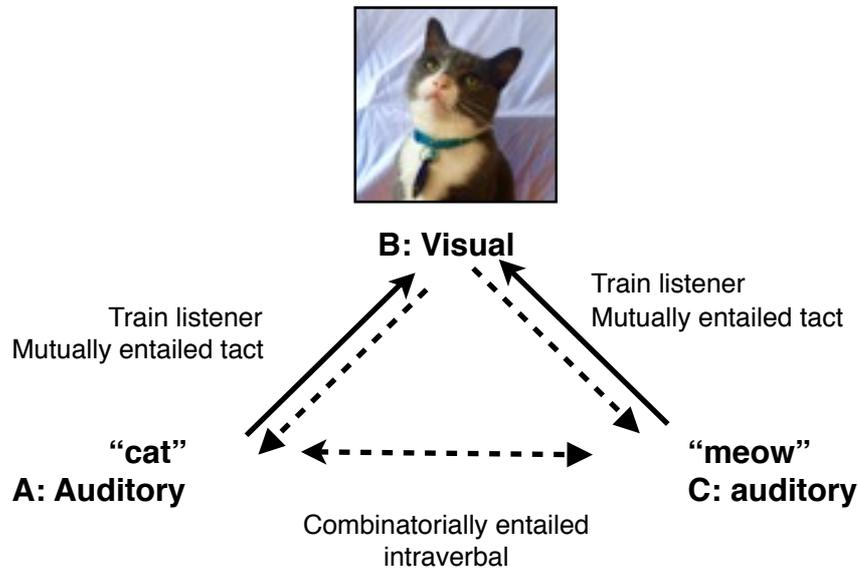


Figure 4.3. Animal-name-sound relations as derived verbal operants.

Type of stimuli. Protocols for assessing derived relational responding, including the standard TARPA as described above, typically employ highly abstract stimuli in match-to-sample (MTS) formats. This is standard practice in the context of training and testing derived relations, because it eliminates the possibility that the participant may already be familiar with at least some of the relations to be derived and thus it allows a valid and reliable assessment of derived relational responding skills that can maximally inform curricular and/or remedial planning. In its standard form, the TARPA uses highly abstract black and white line drawings as visual stimuli, and nonsense CVC words for auditory stimuli. However, it seemed that it might be possible that the use of such abstract stimuli, particularly in the absence of any particular verbal context beyond the match to sample format, may have been a factor impacting the participants' ability to learn the required conditional discriminations (as well as demonstrate DRR) in pilot testing.

A number of studies have found that visual stimuli that are familiar or nameable (i.e. pictures of real items or familiar shapes) (Arntzen & Lian, 2010; Eikeseth & Smith, 1992, Dickins, Bentall & Smith, 1993), or which are "meaningful" in the sense of having either pre-existing or taught discriminative

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functions (Fields, Arntzen, Nartey & Eilifsen, 2012), and auditory stimuli that rhyme (Randell & Remington, 1999) or are pronounceable (Mandell & Sheen, 1994), are all more likely to result in demonstrations of derived responding than those which are not. However, others (e.g., Smeets & Barnes, 2005) have found that familiar stimuli can have an inhibitory effect on the formation of equivalence classes.

In the initial studies of assessing and training DRR (presented in Chapters 5 and 6), abstract stimuli were used in order to provide for better experimental control; however, as opposed to the black and white abstract stimuli used in the standard administration of the TARPA, these were more colorful, natural forms (they were in fact drawn by a typically developing 6-year-old child to represent “crazy animals”; see Table 4.1 for examples, and Appendix B for all the stimuli used).

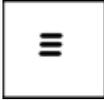
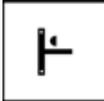
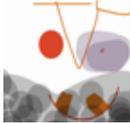
Stimulus Set Type	A (auditory)	B (visual)	C (auditory)
Black and White Abstract	Cug		nem
	Dib		paz
Color Abstract	Aps		boo
	Blab		git
Real Life	Jack		roar
	Ted		ssss

Table 4.1. Example black and white abstract, color abstract, and real life stimuli.

In combination with alterations to the instructional context as discussed previously, it was thought that these stimuli might be more motivating for students and would be sufficiently supportive of students' DRR repertoires to overcome the difficulties seen during the early pilot testing, while still retaining sufficient control with respect to participants' previous learning histories. However, as will be described in the next two chapters, this modification did not consistently seem to be successful in providing for an accurate picture of very early emergent DRR, and the final training protocol thus used photos of familiar animals.

Frames of Coordination

Chapter 5:
Exploring Variables that Influence Assessment of DRR

Portions of this chapter have been previously published in:

Ming, S., Stewart, I., McElwee, J., & Bynum, K. (2015). Contextual control over derived relational responding in a teenager with autism. *Research in Autism Spectrum Disorders*, *19*, 7-17 doi:10.1016/j.rasd.2015.03.003.

Assessment Variables

The first step in any intervention program is assessment, and as described in the previous chapter, there are a number of variables that might affect such assessment with respect to individuals' ability to demonstrate derived relational responding. The first studies in the current line of research focused in particular on the effect of one of these variables, that of the instructional context that is provided for training. These first studies involved the Training and Assessment of Relational Precursors and Abilities (TARPA; Moran, Stewart, McElwee & Ming, 2010, 2014; Moran, Walsh, Stewart, McElwee & Ming, 2015) as the protocol for some of the core training and testing procedures. Standard TARPA administration uses abstract stimuli in a typical match-to-sample context for providing instruction during conditional discrimination training. That is, participants are asked to identify which stimulus "goes with" a sample, or which one is "the right one". However, as noted in the previous chapter, it was determined that a more motivating and meaningful context should be used for training purposes as multiple exemplar training (MET) was investigated. Thus, the TARPA as initially designed to be used for MET employed abstract stimuli in the context of a "game" about animals and their names and the sounds that they make. Two studies will be described in this chapter that explore the effect of this context, as well as a third that additionally explored stimulus type, on the demonstration of derived relational responding. In all the studies, participants were exposed to both the standard TARPA and the TARPA using the animal game context, as will be described below. All initial assessment in these studies involved completely abstract stimuli, and the training and testing of the relations presented these abstract stimuli in two different contextual conditions: a) a neutral match-to-sample context and b) a match-to-sample context presenting abstract stimuli as the names and sounds of "animals" (see Figure 5.1). The final study further used the animal context along with familiar pictures of "real life" animals.

Assessment Variables

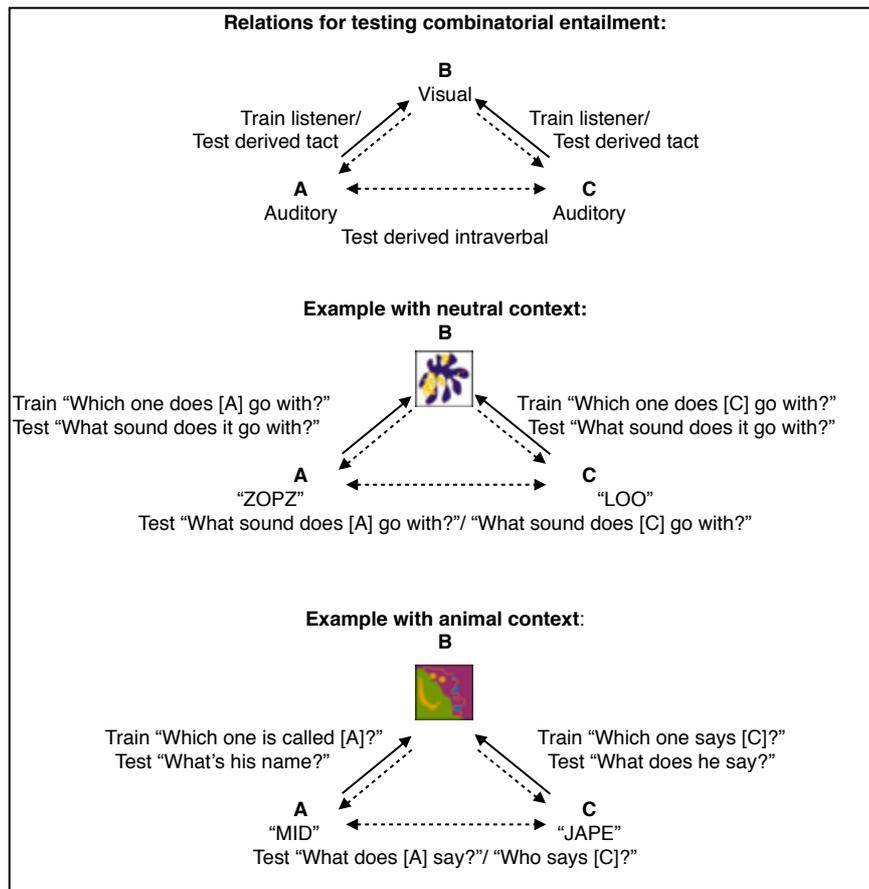


Figure 5.1. Trained and tested stimulus relations in the neutral and animal game contexts.

Study 5.1 presents data from a small number of separate (n=1) cases involving the animal game context. In each case, participants were first exposed to the TARPA in its original, standard form, which used black and white abstract stimuli in a neutral match-to-sample context, and then to the animal game using colored abstract stimuli designated as “animals”. A brief follow-up test was then done with one of the participants using the colored stimuli in both conditions. Study 5.2 (Ming, Stewart, McElwee & Bynum, 2015) consisted of an ABAB reversal demonstrating the effects of context alone on DRR performance for a teenager with autism. Study 5.3 used a multiple baseline design, with abstract stimuli in both the neutral MTS context and in the animal game context, and then, based on participant performance,

real life stimuli were used in both tabletop and computer-based presentations. All three studies were conducted to provide further information on the emergence and assessment of DRR in individuals with relatively undeveloped repertoires of DRR as well as to provide additional empirical investigation of the theoretical link between DRR and language as postulated by RFT.

General Methods

Dependent variable

The dependent variable was accuracy of responding during tests of either mutual or combinatorial entailment. For example, for combinatorial entailment, having been trained on relations of A-B and C-B, did the participant respond correctly on tests of A-C and C-A? A correct response was defined as selecting A1 in the presence of C1 or vice versa, and selecting A2 in the presence of C2 or vice versa, while incorrect responses were defined as any other selections or no response (although nonresponding never occurred).

General Procedures

In all sessions, the administrator and student sat next to each other at a table facing the computer screen. The teaching procedure for all conditional discrimination training phases consisted of the administrator first *demonstrating* the correct response (touching the sample, giving the relevant contextual cue, and touching the correct comparison), then *guiding* the student (e.g., saying, “Let’s do it together”), and then instructing the student to complete an *independent* trial (e.g., saying, “Now it’s your turn, you do it”). This is referred to in the TARPA manual as the Demonstration Guidance Independent (DGI) protocol. Correct responses were followed by praise and computer-delivered reinforcement (brief sounds, such as clapping, and a display of an array of small pictures of smiley faces, stars, etc.). In addition, praise and tangible reinforcers were delivered contingent on correct responding and completion of sections of the TARPA program during all training sessions on the schedule identified by the student’s classroom teacher as appropriate to a learning session.

Stimuli

Figure 5.2 shows the onscreen format for visual-auditory (tact), auditory-visual (listener) and auditory-auditory (intraverbal) discrimination tasks. For each trial, first the sample appeared 1,000ms into the trial. If the sample was visual, a picture appeared in the center of screen, while if the sample was auditory, a red square appeared in the center of screen accompanied by the auditory stimulus. When the student touched the sample, the comparisons appeared 1,000ms later. If the comparisons were visual, pictures appeared simultaneously in the screen corners, while if they were auditory, red squares appeared in succession in a number of screen corners, each accompanied by a particular auditory stimulus. The comparisons appeared in random locations each trial. Auditory stimuli (both sample and comparisons) could be replayed by touching the sample (the center red square). See Table 5.1 for examples of the stimulus sets that were used (see Appendix B for a full list of all stimulus sets).



Figure 5.2. Onscreen format of the TARPA for training and testing visual-auditory, auditory-visual and auditory-auditory stimulus relations.

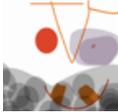
Stimulus Set Type	A (auditory)	B (visual)	C (auditory)
Black and White Abstract	Cug		nem
	Dib		paz
Color Abstract	Aps		boo
	Blab		git
Real Life	Jack		roar
	Ted		ssss

Table 5.1. Example black and white abstract, color abstract, and real life stimulus sets.

Training and testing phases

Conditional discrimination training. Figure 5.3 shows the designated sequence of training and testing stages used in the case of each stimulus set and the criteria in place for each type of trial. A conditional discrimination training session continued until the student reached the set termination criterion for that session with respect to either passing (consecutive correct responses) or failing (cumulative errors), or displayed signs of decreased motivation to participate (e.g., requesting to leave, looking around the room rather than at the iPad, talking to himself rather than responding to instructions). Training sessions were repeated until the student passed, unless the student repeatedly and consistently displayed signs of decreased motivation to participate at the beginning of sessions or refused to attend sessions.

Assessment Variables

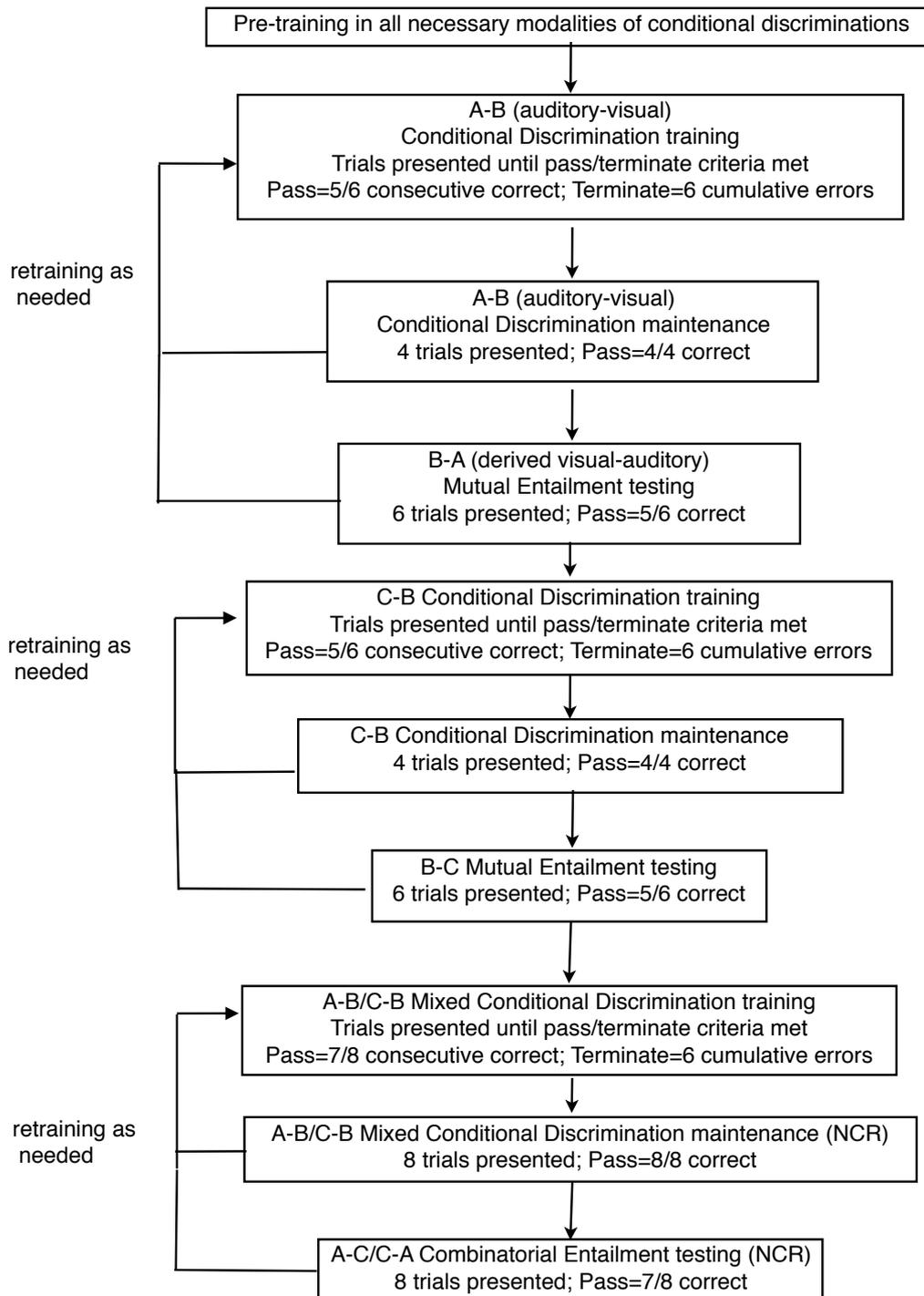


Figure 5.3. Sequence of conditional discrimination training, maintenance testing, and mutual/combinatorial entailment testing.

Conditional discrimination maintenance. Following training, a maintenance test was given. In the typical administration of the TARPA, during a maintenance test, computer-delivered reinforcement is absent, though with teacher-delivered praise and correction still provided.

Derivation testing. Following maintenance testing, the relevant derivation test was conducted. During derivation tests, no feedback for incorrect or correct performance was provided. Occasional general praise may be provided for maintaining appropriate learner behavior (e.g., “You’re working really hard”) when a new sample is presented, but before it has been touched. If the student did not pass a test for derived relations, training and maintenance testing were repeated using the same stimulus set, and the test was then repeated.

Data collection and procedural fidelity. Sessions were conducted by the author and by the behavior analysts who worked at the schools where the participants were enrolled. The behavior analysts were trained in the use of the TARPA program until they reached 100% procedural integrity on both conditional discrimination training and derivation testing trial types. The checklist for implementation from the TARPA manual (see Appendix C) was used for assessing procedural integrity with respect to environmental arrangements, use of the DGI correction procedure, and use of reinforcement appropriate to the type of trial. In addition, the use of cues specific to the experimental phase in effect (neutral or animal context) was assessed. To be considered a correct trial, all elements of the trial must have been performed in accordance with the checklist. For each observation, the total number of correctly performed trials was divided by the total number of trials observed and multiplied by 100%. Either 5-minute probes of sessions were observed via video (10% of sessions) or full sessions were observed live (8% of sessions) for procedural integrity throughout the course of the studies, across both conditional discrimination training trials and derivation testing trials.

Data on all trials were collected automatically by the TARPA program, so inter-observer agreement was not collected per se. Manually tracked data were compared to electronic data files for every session. In addition, the administrator also noted whether or not each stage/level was passed on the *TARPA Tracking and*

Assessment Variables

Summary Sheet (see Appendix A) to ensure the appropriate progression of training and testing in a session.

Study 5.1: Single case investigations of context

The first study represents the initial investigation of the effect of the animal game context on participants' ability to demonstrate DRR in terms of both mutual entailment and combinatorial entailment. In each of the single case reports involved (Studies 5.1.1, 5.1.2, and 5.1.3, as detailed further below), participants were first exposed to the standard, black and white abstract format of the original TARPA, before being exposed to the animal game context using abstract colored stimuli. Subsequent testing involved different combinations of context and stimulus type for each participant; hence each case will be considered separately.

Method

Participants and Setting. All participants were students with independent diagnoses of ASD, who were enrolled in nonpublic schools that provided 1:1 and group ABA-based intensive educational services based on an analysis of verbal behavior model of assessment and intervention. Participants were identified by their teachers as students who were able to quickly learn tact and listener discriminations as well as intraverbals, but whose intraverbal skills were generally described as "rote" in that the students rarely demonstrated untaught or unscripted responses. Six participants were screened for further testing; three of these were included for research participation on the basis of being able to learn the relevant types of conditional discriminations quickly (auditory-visual, visual-auditory, and auditory-auditory, within one or two sessions per relation) and yet not pass tests of combinatorial entailment (two participants) or mutual entailment (one participant).

5.1.1 Case Study 1 [Paul]. Paul, age 7 years 10 months at the beginning of the study, had an independent diagnosis of Autism. Paul had achieved all tact and listener milestones on the Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008b), and almost all intraverbal milestones, placing him at the top of Level 3 on the VB-MAPP and indicating a tact, listener, and

intraverbal vocabulary of over 1000 words with an approximate developmental language level of 42-48 months.

5.1.2 Case Study 2 [Bob]. Bob, age 6 years 1 month at the beginning of the study, had an independent diagnosis of PDD-NOS. Bob had achieved most of the Level 3 tact and listener milestones on the VB-MAPP, and many of the intraverbal milestones, indicating a tact, listener, and intraverbal vocabulary of over 1000 words and an approximate developmental language level of 36-42 months.

5.1.3 Case Study 3 [Chris]. Chris, age 13 at the beginning of the study, had a diagnosis of ASD and was enrolled in a nonpublic school that provided 1:1 and group ABA-based intensive educational services using a verbal behavior model of assessment and intervention. He was identified by his teachers as a student who could quickly learn tact and listener discriminations as well as intraverbals, but whose intraverbal skills were rote, in that he rarely showed untaught or unscripted responses. He had achieved almost all tact and listener milestones on the VB-MAPP and almost all intraverbal milestones, indicating a tact, listener, and intraverbal vocabulary of over 1,000 words, placing him at the top of Level 3 on the VB-MAPP with an approximate developmental language level of 48 months.

Procedures. All sessions were conducted using the TARPA protocol for SAME relations, as described in the *General Methods* section above. All participants were screened first to ensure they could acquire the necessary conditional discriminations using the TARPA, as well as for demonstration of derived tact, listener, and intraverbal responses given two different training modalities: a) train tact (visual-auditory), derive mutually entailed listener (auditory-visual) and combinatorially entailed intraverbal (auditory-auditory) responding, and b) train listener, derive mutually entailed tact and combinatorially entailed intraverbal responding.

Sessions were conducted in a separate room in the school where each student was enrolled, and each session lasted from 20-30 minutes. Sessions were conducted from one to three times per week depending on participant and researcher availability, illnesses, school holidays, and other absences.

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The neutral condition initially used black and white stimuli as this had been the standard format of the TARPA in previous studies (Moran, Stewart, McElwee & Ming, 2010, 2014). Verbal instructions in this condition were appropriate for a typical match-to-sample context (e.g., “find the right one” or “which one does it go with?”). The animal condition used colored drawings of abstract shapes. In these sessions, the student was first instructed that he was going to learn about some strange animals (B stimuli) and what their names were (A stimuli) and what they said (C stimuli). Verbal instructions used during training and testing were appropriate to the animal context, such as “what’s his name?”, “which one is called [x]?”, “what does he say?”, “which one says [x]?”, or “what does [x] say?” (see Figure 5.1). Each participant was initially tested with the neutral context with black and white stimuli, and then the animal context with colored stimuli. Further assessment varied by participant in terms of the type of stimulus used in each context, as will be described below for each case.

Data collection and procedural fidelity. Sessions were conducted by the author and by one of the behavior analysts who worked at the school where one of the participants was enrolled. Procedural fidelity probes were conducted as described above for *General Methods*, with all probes indicating procedural integrity to be at or above 90%. The only errors observed during implementation were in the use of the DGI correction procedure during conditional discrimination training trials when the instructor failed to adjust the touchscreen program quickly enough to be able to provide correction before the participant could self-correct. Procedural integrity during derivation test trials was 100% for all probes. As described above, data on all trials were collected automatically by the TARPA program, so inter-observer agreement was not collected per se. Manually tracked data for all test sessions were compared to electronic data files for all sessions, with 100% agreement.

Results and Discussion

5.1.1 Case Study 1 [Paul].

Conditional Discrimination Training. Results of conditional discrimination training for Paul are shown in Figure 5.4, indicating the average number of training

trials required to meet criterion in maintenance tests prior to each derivation test. Average training trials required to reach criterion for testing showed no difference between abstract and context conditions for mutual entailment tests. However, average training trials required to reach criterion for testing showed more trials required for abstract than context conditions for combinatorial entailment, possibly reflecting an increased level of difficulty when the task required mixing A-B and C-B discriminations without the context of the animal game.

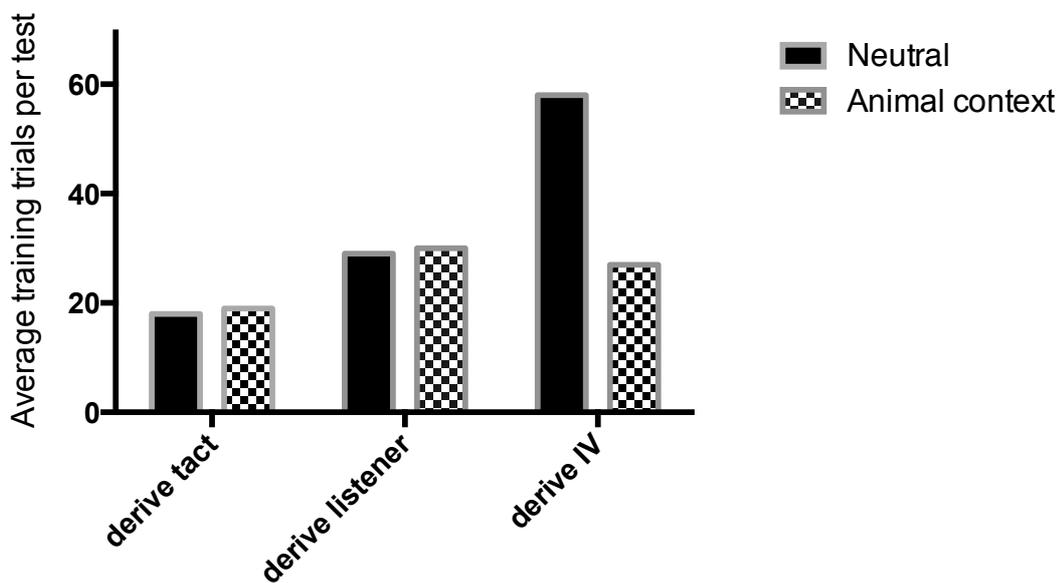


Figure 5.4. Results for Paul: Average conditional discrimination training trials required to reach criterion for testing in the neutral and animal conditions, for mutually entailed derived tact and listener relations and for combinatorially entailed derived intraverbal relations.

Derivation Testing. Results of mutual entailment derivation testing for Paul are shown in Figure 5.5. Paul failed tests of mutual entailment for derived tact responding (stimulus set 1), failed tests of mutual entailment for derived listener responding in the neutral condition (stimulus set 2). He then passed the first test of mutual entailment for both derived tact (stimulus set 3) and derived listener (stimulus set 4) responding in the animal condition. He subsequently passed tests of mutual entailment in both derived tact (stimulus set 1) and derived listener (stimulus set 2)

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responding in the neutral condition. In all cases, the stimuli used in the neutral condition were black and white abstract stimuli, while the stimuli used in the animal condition were colored abstract stimuli.

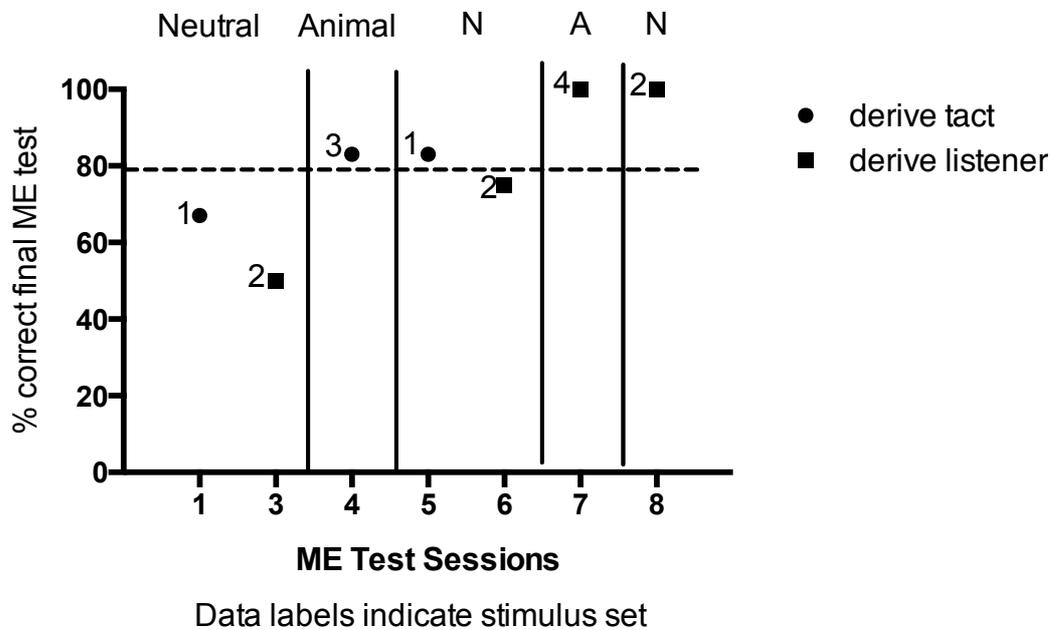


Figure 5.5. Results for Paul: Percentage correct in final (i.e. first or second in the case of a pass, or second in the case of a failed test) mutual entailment tests for derived tact and derived listener responses under neutral and animal context conditions. Pass is indicated at 5/6 correct. Chance responding based on a comparison array of 2 would be 50% correct.

After Paul had passed mutual entailment tests for both tact and listener responding, he was tested on combinatorially entailed derived intraverbal responding; these results are shown in Figure 5.6. He failed tests of CE in the neutral condition (stimulus set 2), and then passed the first test in the animal condition (stimulus set 4). He then again failed the test of derived intraverbal responding in the neutral condition (stimulus set 2). At this point, Paul exited from the program in which he was enrolled.

Approximately one year after the conclusion of initial testing, a follow-up opportunity became available with Paul, at which point additional testing was conducted. During follow-up testing, to control for differences in the type of stimuli

used in each condition, colored stimuli were used of the same type as in the animal game condition (see Figure 5.3 for examples of stimuli used; for Paul, sets 3-6 were color abstract stimuli). All other procedures remained the same. This thus allowed for the addition of a reversal condition using the same stimulus types in each phase of testing. Paul again failed tests of derived intraverbal responding in the neutral condition (stimulus set 5), and then passed the first test of derived intraverbal responding in the animal condition (stimulus set 6).

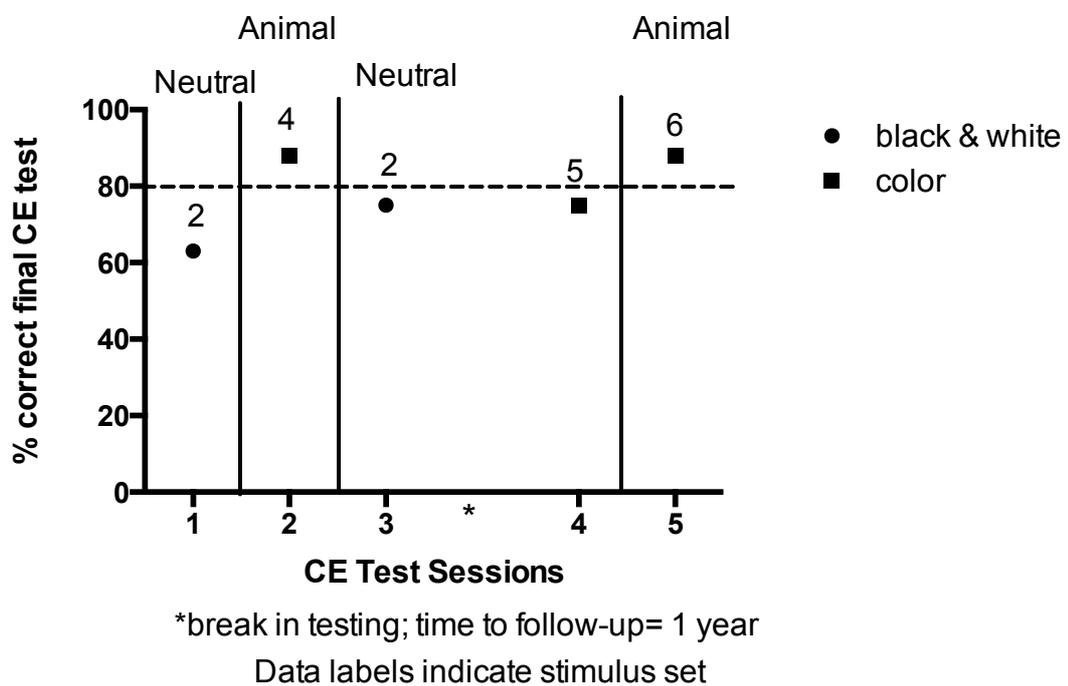


Figure 5.6. Results for Paul: Percentage correct in final (i.e. first or second in the case of a pass, or second in the case of a failed test) combinatorial entailment tests for derived intraverbal responses under neutral and animal context conditions. Pass is indicated as 7/8 correct. Chance responding based on a comparison array of 2 would be 50% correct.

5.1.2 Case Study 2 [Bob].

Conditional Discrimination Training. Results of conditional discrimination training for Bob are shown in Figure 5.7, indicating the average number of training trials required to meet criterion in maintenance tests prior to each derivation test. Average training trials required to reach criterion for testing showed no difference

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between abstract and context conditions for mutual entailment tests. However, as also seen with Paul, average training trials required to reach criterion for testing showed more trials required for abstract than context conditions for combinatorial entailment.

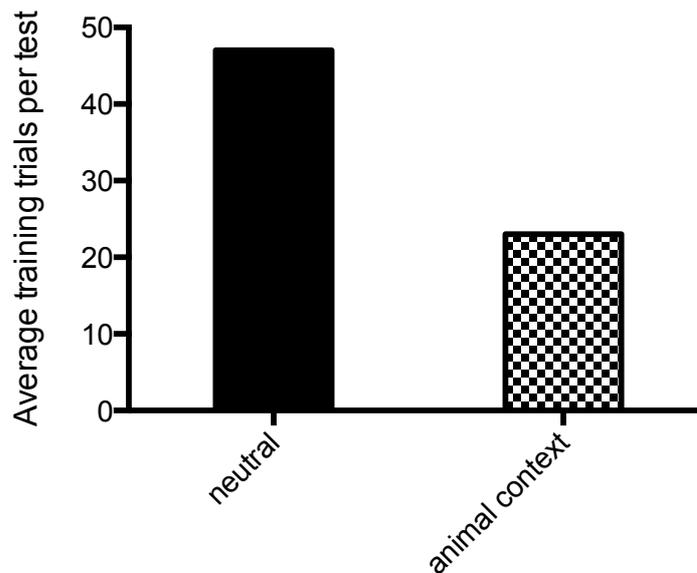


Figure 5.7. Results for Bob: Average conditional discrimination training trials required to reach criterion for testing in the neutral and animal conditions, for combinatorially entailed derived intraverbal relations.

Derivation Testing. Bob's results are shown in Figure 5.8. Testing for combinatorial entailment with trained tact/derived intraverbal relations was discontinued, as he consistently failed to either pass training sessions or to maintain the mixed B-A/B-C relations in the absence of iPad delivered reinforcement. When baseline relations were trained as listener responses, with tests for mutually entailed tact and combinatorially entailed intraverbal responses, Bob failed two initial tests of combinatorial entailment in the neutral condition. He then passed on the second test for combinatorial entailment with a new stimulus set in the animal game condition. At this point, it was decided to test black and white stimuli with the animal game context and color stimuli in the neutral context. Bob failed tests of combinatorial entailment in the animal game context and neutral context with black and white

stimuli, but then passed a test in the animal game context with black and white stimuli (with a previously tested stimulus set). He then failed to pass mutual entailment with color stimuli in the neutral context, but went on to pass combinatorial entailment with a novel set of color stimuli in the animal game context.

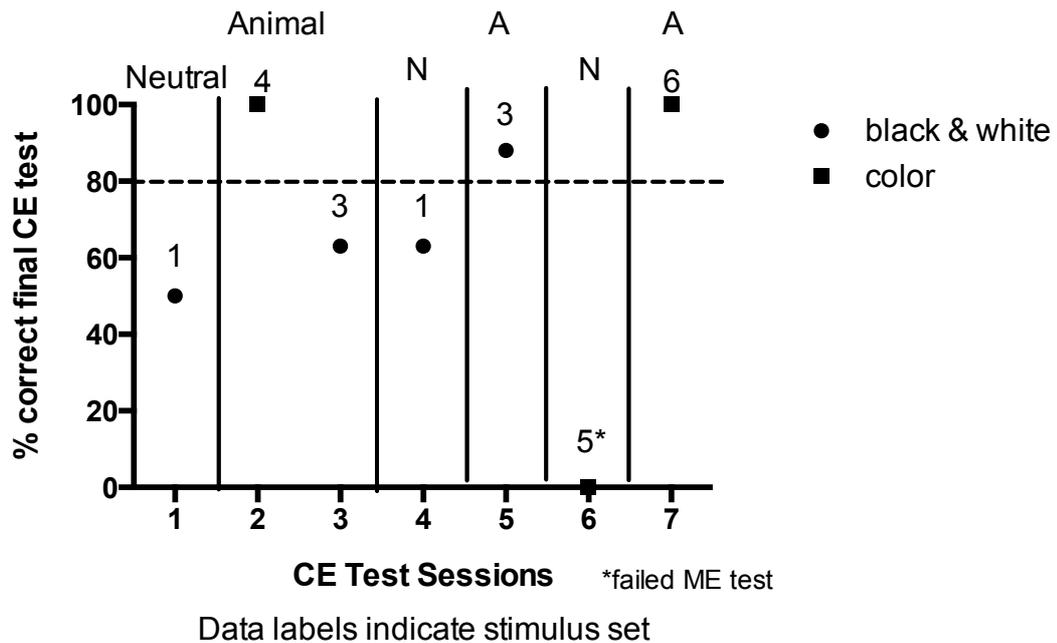


Figure 5.8. Results for Bob: Percentage correct in final (i.e. first or second in the case of a pass, or second in the case of a failed test) combinatorial entailment tests for derived intraverbal responses under neutral and animal context conditions. Pass is indicated as 7/8 correct. Chance responding based on a comparison array of 2 would be 50% correct.

5.1.3 Case Study 3 [Chris].

Conditional Discrimination Training. Results of conditional discrimination training for Chris are shown in Figure 5.9, indicating the average number of training trials required to meet criterion in maintenance tests prior to each derivation test. Average training trials required to reach criterion for testing showed no difference between abstract and context conditions for mutual entailment tests for derived listener relations. Since (as discussed below) Chris passed derivation tests for

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mutually entailed derived tact relations in the neutral condition following exposure to the animal condition with derived listener relations, he was not exposed to the derived tact format in the animal condition.

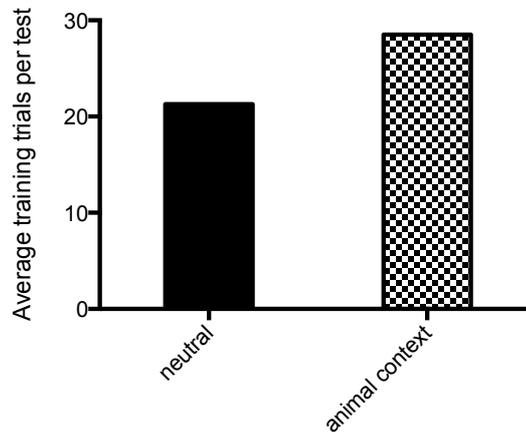
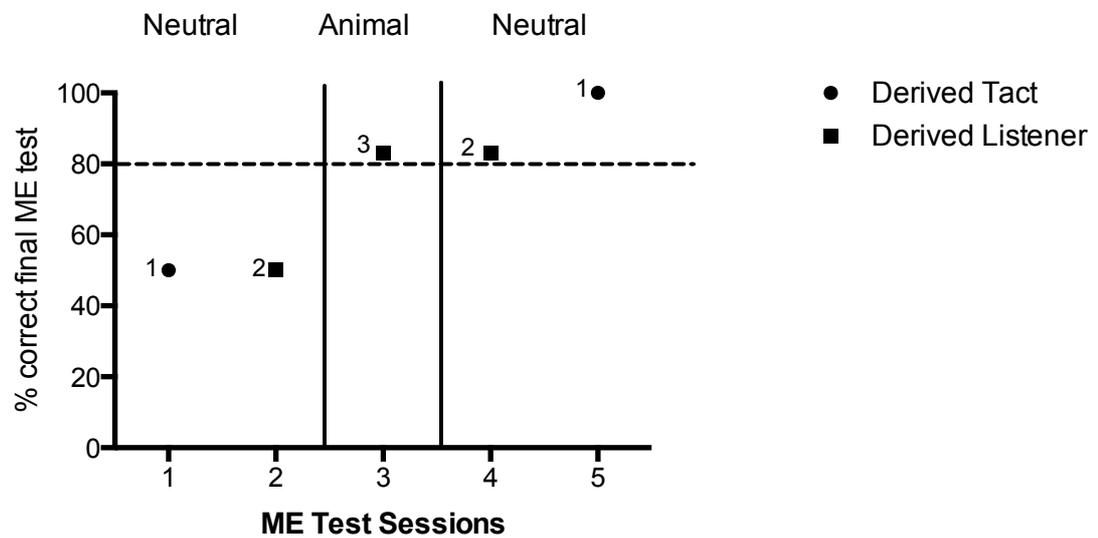


Figure 5.9. Results for Chris: Average conditional discrimination training trials required to reach criterion for testing in the neutral and animal conditions, for mutually entailed derived listener relations.

Derivation Testing. Results of derivation testing for Chris are shown in Figure 5.10. Chris failed two initial tests of mutual entailment for both derived listener and derived tact responding in the neutral condition. He then passed a test of mutual entailment for derived listener responding given the animal game context. He then passed tests of mutual entailment for both derived tact and derived listener responding in the neutral condition (with previously tested stimulus sets).

In summary, the collective results from these three single case studies provided preliminary evidence that the animal game context may be useful for assessing derivation of equivalence relations in young children. The animal game provides a context that may be more efficient for training initial baseline relations, and one which may be more sensitive to early and potentially fragile abilities to derive intraverbals. Since initial testing was conducted with black and white stimuli, it is possible that the color or type of stimuli used was as much a factor as the context provided by the animal game in those initial tests, and since Bob's successful test with black and white stimuli in the animal context was with a stimulus set that had been previously tested, it is also possible that repeated testing, rather than the

context, was an influence on his performance. However, the reversal seen with Paul's performances even with colored stimuli in both conditions lends support to the argument that the animal game context itself was the most important factor in whether or not they could demonstrate derived relational responding abilities. Thus, in the next study, the effect of this context was explored further with Chris, using an ABAB reversal design and controlling for the potential effect of color in the stimulus sets.



Data labels indicate stimulus set

Figure 5.10. Results for Chris: Percentage correct in final (i.e. first or second in the case of a pass, or second in the case of a failed test) mutual entailment tests for derived tact and derived listener responses under neutral and animal context conditions. Pass is indicated as 5/6 correct. Chance responding based on a comparison array of 2 would be 50% correct..

Study 5.2: Demonstrating contextual control¹

The second study presented in this chapter attempted to provide a more controlled demonstration of the influence of the animal naming game context with respect to DRR than had been possible in Study 5.1. The single participant in this study had participated in the first case studies (Chris). Chris was a teenager diagnosed with autism spectrum disorder (ASD) who had significant language delays, such that, in common with the other participants discussed above, he scored at Level 3 of the VB-MAPP. As described above, he was initially unable to demonstrate mutually entailed tact or listener responses with the neutral context. Following the introduction of the animal context, he was able to demonstrate mutual entailment both with that context and later with the neutral condition, for both tact and listener responses. In this study, the neutral MTS and animal game conditions were compared using a multiple treatments reversal design (Cooper, Heron, & Heward, 2007) for their effect on the likelihood of the demonstration of combinatorially entailed intraverbals.

Method

Participant and setting. As noted above, Chris, age 15 at the beginning of this study, had initially been involved in the first case studies of this series. At the time of this second study, his language level was tested using the Peabody Picture Vocabulary Test (PPVT), which indicated an age equivalent of 48 months. This result is consistent with his VB-MAPP scores (Level 3), as previously reported in Study 5.1.3 above. With an age equivalent of 48 months, it might be expected based on previous work with typically developing children that an individual would be able to demonstrate combinatorial entailment (e.g., Lipkens, Hayes & Hayes, 1993; Luciano, Gomez-Beccerra, & Rodriguez-Valverde, 2007; Pelaez, Gewirtz, Sanchez, & Mahabir, 2000). However, neither the PPVT nor the VB-MAPP directly assess

1. This study has been previously published as: Ming, S., Stewart, I., McElwee, J., & Bynum, K. (2015). Contextual control over derived relational responding in a teenager with autism. *Research in Autism Spectrum Disorders*, 19, 7-17. doi:10.1016/j.rasd.2015.03.003

DRR skills, and thus may not reflect any DRR repertoire regardless of age-equivalency. In fact, and of critical importance, Chris was able to pass tests of auditory-visual mutual entailment, but was not able to pass tests of auditory-auditory combinatorial entailment, using the standard (neutral context) version of the TARPA.

This study was carried out in a separate room at the school where Chris was enrolled with one research assistant who was a Board Certified Behavior Analyst (BCBA) and who was familiar with Chris. Sessions typically lasted 20-30 minutes and were generally held once or twice a week, barring absences for illnesses, school holidays, and participant and researcher availability, over the course of approximately a year.

Data collection and procedural fidelity. Sessions were conducted by the behavior analyst at the school where Chris was enrolled. Procedural fidelity was assessed using the same checklist and procedures as described above for *General Methods* with all probes indicating procedural fidelity at or above 90%. Electronic data files were compared to session data for 95% of sessions, with 100% agreement. Manually tracked data for 100% of combinatorial entailment derivation tests were compared with electronic data files, with 100% agreement.

Experimental Design. The study used an ABAB multiple treatments reversal design in which each phase involved training conditional discriminations and testing for combinatorial entailment for each of two different stimulus sets. The A phase involved the neutral condition for both training and testing, while the B phase involved the animal condition for both training and testing. Instructions used in each condition were as described above in the *General Methods* section (see Figure 5.1).

Results

Conditional Discrimination Training. Results of conditional discrimination training are shown in Figure 5.11. This shows the average number of training trials required to meet criterion in maintenance tests prior to the first combinatorial entailment test for each stimulus set. Average training trials required to reach criterion for combinatorial entailment testing showed in general more trials required during Phase A (neutral) than Phase B (animal) conditions, with an average of 214

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trials required to reach criterion for sets in the neutral condition compared to 93 for sets in the animal condition.

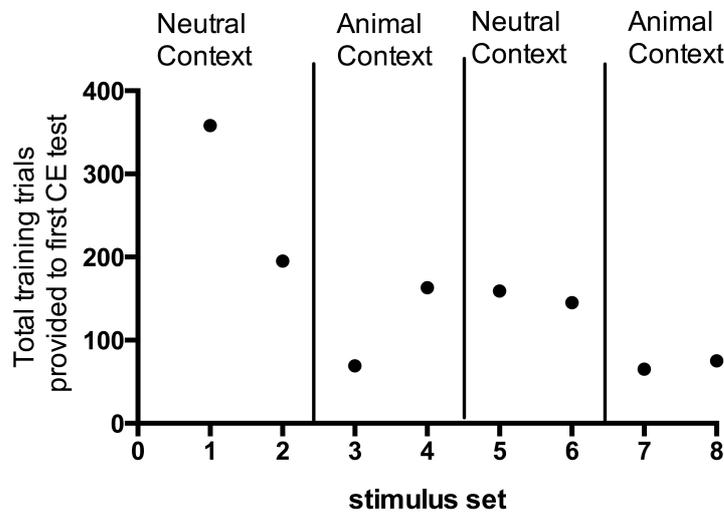


Figure 5.11. Results for Chris: Total conditional discrimination training trials required to reach criterion for testing in the neutral and animal conditions, for each stimulus set.

Derivation Testing. Results for the final combinatorial entailment test in the case of each stimulus set are shown in Figure 5.12. Chris failed tests of combinatorial entailment with two stimulus sets in the neutral condition (Phase A). In the case of the first set, he failed both tests. In the case of the second set, only one combinatorial entailment test was conducted due to persistent escape-motivated behavior (e.g., requesting to leave), despite the use of noncontingent reinforcement. He was then exposed to the animal condition (Phase B), in which he progressed through conditional discrimination training quickly and then passed tests of combinatorial entailment for both stimulus sets (on the first test of the first stimulus set and on the second test for the second stimulus set). Upon returning to testing in the neutral condition (Phase A), he again failed both tests of combinatorial entailment for each of the two stimulus sets involved. He was then exposed once again to the animal condition (Phase B). In the case of the first stimulus set, he acquired the conditional discriminations quickly and passed the first test. In the case of the second stimulus set, multiple sessions were required for training the initial conditional discriminations and Chris failed two tests, albeit with a borderline score

(6/8) each time. Escape-motivated behavior was noted particularly during the second test. Given the latter and the fact that a borderline score was achieved for both tests, it was decided to administer a third test with this set, and on this third test, he scored 100% (8/8).

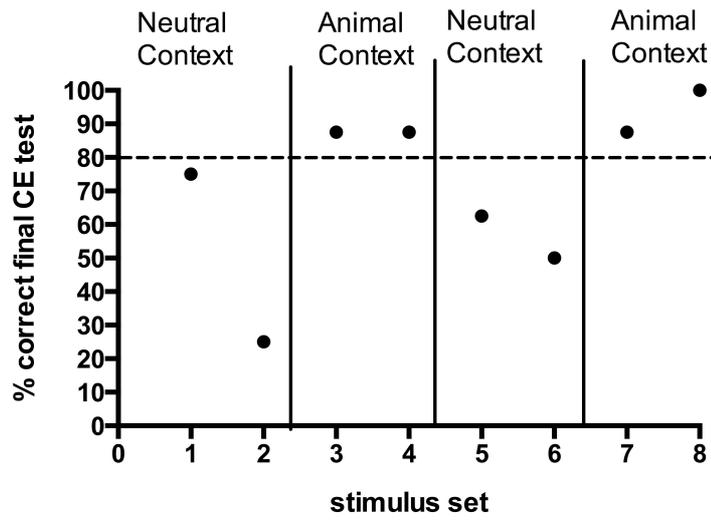


Figure 5.12. Results for Chris: Percentage correct in final (i.e. first or second in the case of a pass, or second in the case of a failed test) combinatorial entailment tests for each stimulus set under neutral and animal context conditions. Pass is indicated as 7/8 correct. Chance responding based on a comparison array of 2 would be 50% correct.

Discussion

This study used a multiple treatments reversal design to compare two different MTS contexts (“neutral” and “animal naming game”) for the training and testing of DRR in a teenager with ASD. Results showed that Chris was unable to demonstrate DRR in the neutral context but was able to demonstrate it in the animal context. In addition, training in the animal context was more efficient, requiring fewer trials to reach criterion for combinatorial entailment testing. It should be noted that with respect to trials to criterion, there was a decrease over time as well, and thus, sequencing effects cannot be ruled out. However, even excluding the first

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stimulus set (which showed the largest difference), average training trials to criterion for the neutral context was 166, compared to 93 for the animal context. The second of the four animal context sets required a similar number of training trials as the neutral context sets, while the other three proceeded more quickly.

While this pattern was hinted at in the case studies presented previously in Study 5.1, this systematic reversal based on context alone was demonstrated in a single individual only, and therefore further research is needed to examine how common such an effect might be. Nonetheless, the current findings have both theoretical and practical significance. These results are similar to those of previous research that have shown that DRR is more likely to occur under certain conditions. For example, previous work has found that the use of familiar stimuli may lead to a greater likelihood of participants passing tests of DRR (Fields, Arntzen, Narty, & Eilifsen, 2012; Holth & Arntzen, 1998; O'Connor, Rafferty, Barnes-Holmes, & Barnes-Holmes, 2009). One key difference between the current study and those just cited, however, is that this study was able to show a level of control over the appearance of DRR, namely, in accordance with a reversal pattern that is *unprecedented* in published research on derived relations. Two factors likely contributed to allowing this pattern to occur. One is that Chris had a repertoire of DRR that was still in the early stages of development and hence was not robustly enough established to be widely generalized making it more likely to be strongly contextually determined. The second was that a particularly powerful context for the appearance of derived coordinate relations, namely, the animal naming game, was used.

With regard to the first of these factors, Chris was deliberately selected. He was initially identified as someone whose intraverbal skills were essentially “rote” in that he rarely showed untaught or unscripted responses, suggesting that a repertoire of DRR was not well-established. More importantly, preliminary testing using the TARPA indicated that he was able to pass tests of auditory-visual mutual entailment but was not able to pass tests of auditory-auditory combinatorial entailment, using the standard (neutral context) version of this test.

As discussed above, subsequent training and testing using similar stimuli, but in the context of the animal naming game, showed that he could pass in this context but also that this performance was strongly contextually determined, since despite passing in the latter, he continued to fail in the neutral context. This, of course, is where the second factor played a key role. As suggested in Chapter 4, for a number of reasons, the animal naming game appeared to have potential to be a strong context for derived relations. For example, this game is very popular in early education. In addition, Lipkens and colleagues (1993) had previously used this context when they successfully showed the initial emergence of derived relational responding in a frame of coordination with a typically developing infant. However, such results were only suggestive, because while they used this context in the demonstration of the initial emergence of derived coordinate relations, they did not compare this context with any other. Thus, they could not conclusively argue for the superiority of this particular context nor in favor of the concept of contextual control over derived relations itself. The results of the present study in contrast, do allow this comparison by juxtaposing the animal context with another context very similar, in many key respects, and showing that derived equivalence emerged only in the former. The data from this study appear to constitute a particularly clear cut example of contextual control over emergent derived relations as well as a demonstration of a particularly powerful context for this phenomenon.

One issue worth considering with respect to the difference between the neutral and animal contexts is the extent to which Chris was motivated to participate in each context. Problems due to motivation (i.e., escape-motivated behavior) appeared in *both* of the conditions, as noted previously. Multiple factors potentially influenced Chris's motivation to participate in these sessions including competing activities in the classroom at the time of the session, frequency of sessions during the week, and environmental/behavioral variables that were impacting Chris's behavior across the day in multiple settings at those times. Nonetheless, it is possible that the animal context, having been previously paired with reinforcement, was itself more motivating than the neutral context, which could have affected his performance. Stimuli in the animal context may have functioned to an extent as reinforcers on the

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basis of this previous pairing, thus enhancing Chris's attention during these sessions. This seems possible with respect to the difference between the trials to criterion required for the neutral versus animal context sessions. However, in each context, the derivation tests occurred only after Chris demonstrated 100% performance on tests of the conditional discriminations and occurred only if he was not exhibiting any behaviors indicating a decreased motivation to participate, thus making it less likely that attention and motivation constituted a significant factor in testing performance.

Assuming that differential stimulus control was indeed the primary factor responsible for these results, then one approach with which the current data are consistent is RFT, according to which DRR is explicitly explained as a contextually controlled repertoire established by multiple exemplar training provided in the course of (typically natural) language interactions. In accordance with this conception, previous RFT studies have deliberately manipulated context in order to systematically influence patterns of DRR. However, as suggested, the current study involved working with an individual whose level of language skills was particularly low and thus the current data arguably provide a particularly clear cut example of contextual control. There has as yet been relatively little work investigating the role of contextual control in DRR in individuals with such low levels of verbal skill. Perhaps an effect such as attained here might not be attainable in someone at a higher level of verbal ability. Further work with individuals at varying language levels might be needed to explore this suggestion. In any event, results such as these arguably boost our level of insight into the influence of contextual control in the context of derived relations.

At a practical level, the findings of this study have utility for both assessment and training purposes. Children with ASD may be quite sensitive to the effects of context; research over many decades certainly has pointed to the difficulty many children with ASD have with stimulus generalization and overselectivity (e.g., Wilhelm & Lovaas, 1976), and this may extend to the effect of instructional context on DRR. These results highlight the importance of attending to variables that will facilitate or hinder demonstration of existing skills when conducting assessments, so as to get an accurate picture for program development. For example, the animal

context might make it more likely for children with a very early DRR repertoire to show skills that might not otherwise be detected during assessments. When training, such a context might constitute a useful foundation for strengthening and extending an emergent repertoire.

Future research is needed to address some limitations of the current work. One such limitation, as mentioned earlier, is the fact that although the results in Study 5.1 lend additional support to the conclusions here, those studies were not well controlled, and the data in the current study were shown for only one participant. It would be informative to examine how readily this effect might be seen in those with emergent derived relational skills as well as to further explore the conditions under which it occurs. In addition, in regard to the latter, one factor that might bear further examination is the ordering of the animal and neutral contexts. Of course, the variable of sequencing is already controlled to some extent in a reversal design. However, which condition comes first is still a potentially important factor. For example, it is difficult to know the extent to which the length of the training needed in the initial, neutral phase of the current study was a factor of involving the first phase or of involving the neutral context. Both issues discussed here (i.e., size and counterbalancing of order) could be attended to in future research involving multiple participants across whom order is counterbalanced.

In addition to the need for further systematic exploration of the effect of context, however, the results of these first two studies strongly implied the need to study other variables that might impact the assessment of DRR with early learners. Any assessment used with individuals with either no repertoire of DRR, or a very fragile one, must be able to capture whether or not they can derive relational responses under any set of circumstances. Context itself is potentially a major factor in the demonstration of DRR, and as discussed in the previous chapter, the type of stimuli used may also be an important factor to carefully consider when assessing DRR with this population. In the final study presented in this chapter, the influence of both context and stimulus type in assessment was explored.

Study 5.3: The effect of context and stimulus type in assessment of DRR

The third study presented in this chapter further examined the effect of instructional context, and also demonstrated the effect of stimulus type. The study was initially planned to provide a multiple baseline demonstration of the effect of context. A case study on multiple exemplar training that had been conducted in the meantime, following Study 5.1 (as will be described further in Chapter 6 (Study 6.1)), had found that some children who could not demonstrate DRR with the colored abstract stimuli in the animal context could ultimately do so using pictures of real animals (“real life” stimuli). As discussed in the previous chapter, there is also other research to suggest that familiar stimuli can have an important effect on the demonstration of DRR as well (O’Connor, Rafferty, Barnes-Holmes & Barnes-Holmes, 2009; Holth & Arntzen, 1998; Fields, Arntzen, Nartey & Eilifsen, 2012). Thus, following unexpected performance by both participants—neither responded to the introduction of the animal game context—real life stimuli were used, and the effect of that stimulus type on DRR was demonstrated.

The intent of the current study was in line with the aim of the thesis of exploring early emergent repertoires of DRR, which necessitated the development of an assessment and training tool that could identify children who clearly did not have a repertoire of DRR, and then train them in that repertoire. This study aimed to further explore the impact of assessment variables on the demonstration of DRR, so as to provide clearer recommendations moving forward regarding the best format and procedures for initial assessments and subsequent training of early developing relational responding skills. Initial testing was conducted with two children with autism, using abstract, colored stimuli, first in a neutral condition, then with the animal game context, and then real life stimuli were used in the animal game context.

For practical purposes, given the varying schedules of attendance of students at the clinic and the availability of the behavior analyst with respect to testing, a nonconcurrent multiple baseline design was used. As Hayes (1985) and Zhan and Ottenbacher (2001), for example, have noted, a nonconcurrent design allows for greater flexibility in an applied setting, while still promoting internal validity and

experimental control (Christ, 2007). Moreover, given the stability of responding in baseline and the immediate change to the dependent variable with the introduction of the independent variable, as seen in pilot work, the potential threat of history to internal validity was not considered to be significant enough to outweigh the practical benefit of using the design. In keeping with recommendations by Watson and Workman (1981) and Christ (2007), participants were randomly pre-assigned to different baseline lengths.

Methods

Participants and Setting. Both participants were students with independent diagnoses of ASD, who were enrolled in a clinic that provided 1:1 and group ABA-based educational services based on an analysis of verbal behavior model of assessment and intervention. Participants were identified by the directors of the site as students who were able to quickly learn tact and listener discriminations as well intraverbals, but whose intraverbal skills were generally described as “rote” in that the students rarely demonstrated untaught or unscripted responses. Seven participants were screened for inclusion in this study; two of these were included for participation on the basis of being able to learn the relevant initial conditional discriminations quickly (within one or two sessions of no more than 20 trials each), being able to demonstrate mutual entailment, but not being able to pass initial tests of combinatorial entailment.

Bill, age 6 years 8 months at the beginning of the study, had achieved most tact and listener task items on the Assessment of Basic Language and Learning Skills-Revised (ABLLS-R; Partington, 2006), and spontaneously used multiple word phrases when speaking. His intraverbal repertoire as assessed on the ABLLS-R was relatively weak, indicating the ability to fill in many phrases associated with common features, functions and classes of items, but little ability to answer questions or carry on a conversation. Dave, age 16 years 6 months at the beginning of the study, had a very similar profile to Bill on the ABLLS-R, indicating strong tact and listener skills but weak intraverbal skills.

Assessment Variables

Procedures. All sessions were conducted using the TARPA protocol for SAME relations, as described in the *General Methods* section above. As previously, all participants were tested for to ensure they could acquire the necessary conditional discriminations and derive tact, listener, and intraverbal responses with two different modalities: a) train tact (visual-auditory), derive mutually entailed listener (auditory-visual) and combinatorially entailed intraverbal responding, and b) train listener, derive mutually entailed tact and combinatorially entailed intraverbal responding.

Sessions were conducted in a separate room in the site where each child was enrolled, and each session lasted from 20-30 minutes. As in the previous studies, there were two conditions tested: a neutral match-to-sample context (neutral condition), and animal game context (animal condition) (see Figure 5.1). Initial stimulus sets for both neutral and animal context conditions consisted of colored abstract stimuli. Since neither participant was able to pass tests with abstract stimuli in the animal game context, testing then proceeded with the animal context using real-life stimuli. Real life stimulus sets consisted of a picture of a familiar animal (e.g., a cow), the auditory sound that animal makes (e.g., “moo”), and a common/familiar “name” for the animal (e.g. “Jane”) (see Figure 5.3 for examples, and Appendix B for all stimuli).

The work in the previous studies had indicated that it was unlikely for students to pass a derivation test due simply to exposure to multiple tests of stimulus sets, provided they had failed testing with at least two stimulus sets; moreover, any effect due to context alone was likely to be seen immediately. Thus, for practical purposes a nonconcurrent multiple probe design was used, with participants pre-assigned to either 2 or 4 stimulus sets in the neutral condition (with up to two tests per stimulus set) following initial screening sets, prior to the introduction of the animal context.

Data collection and procedural fidelity. Sessions were conducted by the author and by the behavior analyst who worked at the site where the participants were enrolled. Procedural fidelity was assessed as in the previous studies, with all probes indicating fidelity above 80%; errors in implementation consisted of the instructor failing to put the program into the “DGI” mode to provide correction

before the participant could self-correct, and the instructor failing to state the instruction on every trial. Neither of these errors was considered to impact the participant’s performance, as both of these error types were due to the participant progressing very rapidly through the training.

Data on all trials were collected automatically by the TARPA program as in previous studies, including manually tracking data for all test sessions for comparison with electronic data files, with 100% agreement.

Results and Discussion

Conditional discrimination training. Results of conditional discrimination training for both participants are shown in Figure 5.13, which displays the average number of training trials required to meet criterion in conditional discrimination maintenance tests prior to derivation testing on each stimulus set. Consistent with previous results, fewer trials were required for both participants to reach criterion when the animal game context was provided. With real life stimuli, both participants could already identify the sounds the animals made, so while these were tested to ensure they reliably responded to instructions with both the taught name and the animal sound, the conditional discriminations involving animal sounds did not need to be trained. Thus, the use of real life stimuli required the fewest training trials to meet criterion for testing for both participants, although there was not a large difference between the animal game context and the real life stimuli for Dave.

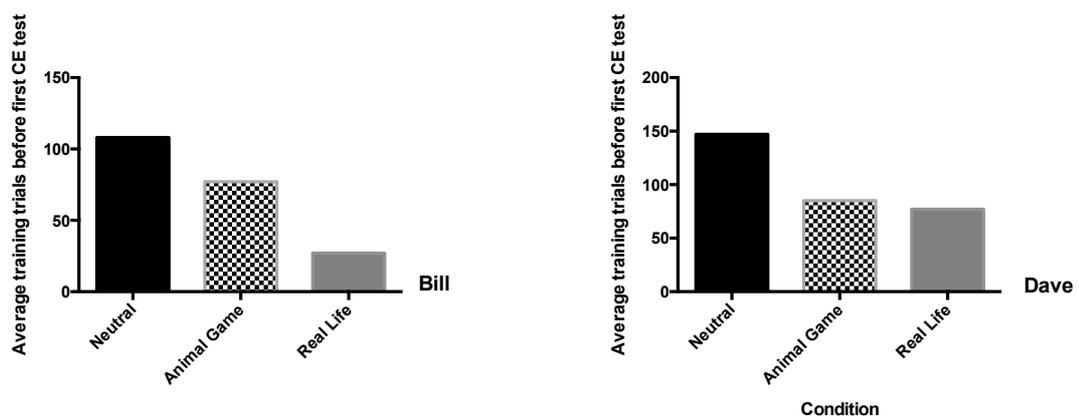


Figure 5.13. Average conditional discrimination training trials required to reach criterion for testing in the neutral, animal, and animal with real life stimuli conditions.

Assessment Variables

Derivation testing. Results for Bill are shown in Figure 5.14, which shows the results for the final derivation test on each stimulus set. Bill initially failed initial tests for combinatorially entailed intraverbals both with trained tact relations and with trained listener relations. He then failed two additional baseline tests for combinatorially entailed intraverbals with trained listener relations. The animal context was introduced; Bill failed at first, and then passed a second test of combinatorial entailment with the first stimulus set in this phase. He then failed combinatorial entailment tests on the next two stimulus sets. The neutral condition was reintroduced, and Bill passed on a second test with the fourth stimulus set. The animal game context was reintroduced and he then failed on two more stimulus sets. Bill’s behavior during testing increasingly appeared to indicate that he was more motivated to “play” with the auditory stimuli, by making his favorite sounds play, rather than attend to the relations as trained and tested—he frequently laughed, repeated the sounds, and repeatedly pressed stimulus buttons, and did so more as time went on with repeated testing. At this point, a real life stimulus set was introduced, and he failed tests of combinatorial entailment with this set as well.

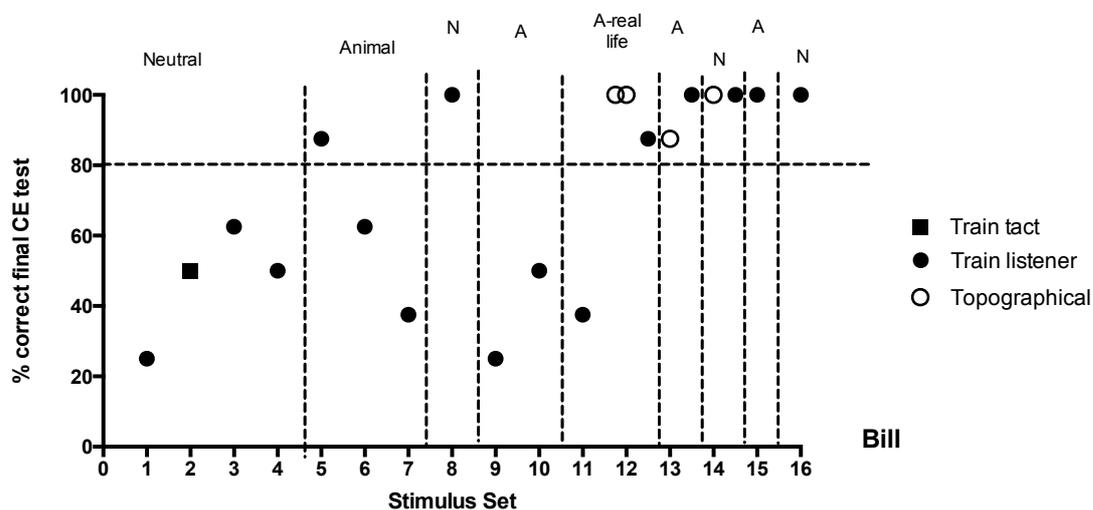


Figure 5.14. Results for Bill: Percentage correct in final (i.e. first or second in the case of a pass, or second in the case of a failed test) combinatorial entailment tests for each stimulus set in the neutral, animal, and animal with real life stimuli conditions. Pass is indicated as 7/8 correct. Chance responding based on a comparison array of 2 would be 50% correct.

Based on Bill's behavior during testing, the decision was made to test his responding using a topographical testing format with real life stimulus sets. In this context, Bill immediately and easily passed tests of combinatorial entailment with the real life stimulus set he had failed iPad based testing with, as well as with a new stimulus set. Training and testing were again conducted on the iPad, and he subsequently passed all tests with novel stimulus sets: real life stimuli with the animal context, abstract stimuli with the animal context, and abstract stimuli in the neutral context.

Results for Dave are shown in Figure 5.15. Based on Bill's earlier performance, Dave was required to vocally tact stimuli during any selection-based tact training or testing levels. Dave failed initial tests for combinatorially entailed intraverbals both with trained tact relations and with trained listener relations. He then failed two additional tests for combinatorially entailed intraverbals with trained listener relations, and then failed mutual entailment tests for CB relations in two subsequent stimulus sets, and failed combinatorial entailment tests in the final set. Although he had been preselected for four MTS sessions after the initial two sets used for screening, based on his inconsistent pattern of responding in these stimulus sets, an additional stimulus set was used. The animal context was introduced, and Dave failed tests of combinatorial entailment with this stimulus set as well. Real life stimulus sets were introduced, and Dave failed combinatorial entailment tests with a first stimulus set and then passed combinatorial entailment tests with a second and third stimulus set, both for derived intraverbals based on trained listener/derived tact and based on trained tact/derived listener. A new stimulus set with the animal context and the abstract stimuli were reintroduced, and Dave failed the first test but passed the second test with this set. Dave then immediately passed a test without the animal context.

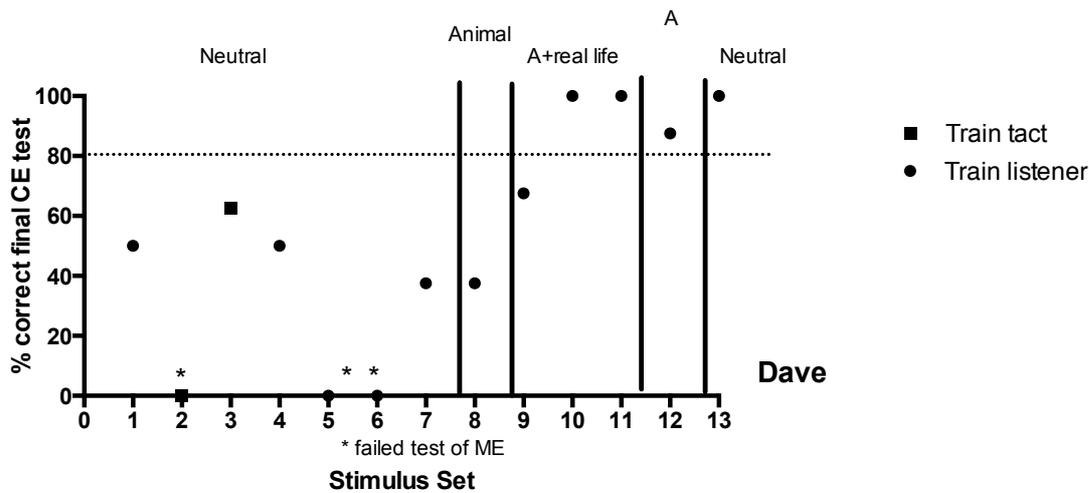


Figure 5.15. Results for Dave: Percentage correct in final (i.e. first or second in the case of a pass, or second in the case of a failed test) combinatorial entailment tests for each stimulus set in the neutral, animal, and animal with real life stimuli conditions. Pass is indicated as 7/8 correct. Chance responding based on a comparison array of 2 would be 50% correct.

While the attempt to demonstrate the effect of context alone when assessing early DRR was not successful in this study, the results did identify additional potentially important variables to attend to which will require further investigation in future work. One of these is the type of stimulus used: both Bill and Dave performed inconsistently until real life (familiar) stimuli were introduced within the animal context, at which point they were subsequently able to demonstrate derived responding in tests with more abstract stimuli and in the neutral context. It should be noted that when using the real-life stimuli, this also reduced the number of *newly trained* relations for the participants: they already were able to identify what sound the animals made, and hence only needed to be trained in the animal's "name". Further work is necessary to isolate the influence of the type of stimuli, the familiarity of the context, and the amount of training needed to establish the baseline conditional discriminations.

The results also highlight an issue to be addressed when selection-based responding is required; that is, the need to ensure that the selection of auditory stimuli is reflective of any topographical responding. For both these subjects, it was

necessary to require topographical responding prior to selection. For Bill, testing with a topographical procedure appeared to be an important factor in facilitating consistent levels of derived responding in a selection-based context. Future research is warranted to investigate differences in performance using topographical vs selection-based responding. For the purpose of the current line of research, data from this study further supported moving to the use of exclusively real life stimuli in both assessment and training. A decision was also made to require future participants to demonstrate topographical responding that was consistent with their selection-based responses during training and testing on the iPad.

General Discussion

This chapter presented three studies examining variables that potentially influence the assessment of DRR with individuals at relatively low levels of verbal abilities, particularly with respect to relations that are critical for language development: auditory-auditory (intraverbal) and auditory-visual (tact/listener) relations. Evidence from the series of studies in this chapter suggested that participants who were not able to demonstrate derived relational responding in a typical MTS context, using abstract stimuli and more general “matching” instructions, were able to do so under other circumstances. The instructional context of animals and their sounds, as well as the use of familiar stimuli and topographical rather than selection-based responding all had impacts to greater and lesser degrees in these studies, and these results have significant practical importance for assessment. Of course there are caveats concerning these outcomes as sufficiently rigorous controls were not in place, especially for Studies 5.1 and 5.3. Nevertheless, these studies do suggest the importance of context as well as other variables, including stimulus type, in the assessment and training of derived relational responding. At a theoretical level, this demonstration is consistent with RFT, according to which derived relational responding is explained as a contextually controlled repertoire established based on multiple exemplar training provided in the course of (typically natural) language interactions. The ubiquity of the animal-name-

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sound context in early language training would make it a prime candidate as a potential cue for the derivation of relations in a frame of coordination.

Previous research has found that the use of familiar stimuli may lead to a greater likelihood of participants passing tests of derived relational responding (O'Connor, Rafferty, Barnes-Holmes & Barnes-Holmes, 2009; Holth & Arntzen, 1998; Fields, Arntzen, Nartey & Eilifsen, 2012). However, for three of the participants in the current studies, it did not appear to be necessary to use familiar stimuli but only a more familiar instructional context. For the other two participants, the use of familiar (real life animal) stimuli within the familiar context of the animal game appeared to result in both a demonstrated ability to derive relations with those familiar stimuli as well as generalization to more abstract stimuli within that context. For both of these participants, this also resulted in generalization to the more general MTS context. As will be discussed further below, future research is needed to better isolate these variables with this population; nonetheless, for all the participants in these studies, some combination of procedural variables related to the use of the animal context during assessment allowed them to demonstrate DRR, when that repertoire had not been demonstrated under the abstract MTS conditions that are more typical of experimental work on DRR.

As suggested previously, the results seen with respect to the effect of the animal game context on the performances of the participants in these studies may stem from the ubiquity of the animal-name-sound context in early language training—it is a highly familiar context, whereas the matching of abstract auditory and visual stimuli on an iPad is not. Similarly, Pilgrim, Jackson & Galizio (2000) found that the use of thematic matching—a familiar context—as an intermediate step between identity and arbitrary matching (i.e. arbitrary visual-visual conditional discriminations) led the young typically developing children in their study to be able to acquire arbitrary matching when they had not previously, suggesting that this step capitalized on the participants' pre-existing experimental histories, and pointing to the importance of such contexts in training. The studies in this chapter support and extend those conclusions, not only with respect to teaching arbitrary conditional discriminations but also with respect to demonstrating derived relational responding.

These results are also consistent with those of Arntzen and Lian (2010), and Fields, Arntzen, Nartey and Eilifsen (2012) with respect to influence of the type and “meaningfulness” of stimuli on demonstrations of equivalence with typically developing children. Arntzen and Lian (2010) found that the use of pictures rather than abstract stimuli resulted in more children demonstrating equivalence as well as resulting in a greater likelihood of later demonstrating equivalence when tested with abstract stimuli. Fields and colleagues (2012) found that establishing “meaning” for otherwise meaningless stimuli by training a discriminative function also facilitates the demonstration of DRR. The current research provides some additional (though preliminary) evidence for the importance of these variables when assessing individuals with early emergent DRR repertoires, highlighting both the potential barriers to the demonstration of such early skills, as well as potential strategies to ensure a more valid identification of any pre-existing repertoires.

At a practical level, the findings of these studies have utility for both assessment and training purposes. Children with autism may be quite sensitive to the effects of context, as well as to the effect of the type of stimulus used; research over many decades certainly has pointed to the difficulty many children with autism have with stimulus generalization and overselectivity (e.g., Wilhelm & Lovaas, 1976), and this may extend to the effect of instructional context on derived relational responding. When conducting assessments, the context of the animal game might make it more likely for children with a very early derived relational responding repertoire to show skills that might not otherwise be detected. When training, such a context might constitute a useful foundation for strengthening and extending an emergent repertoire.

Further work is needed to more systematically replicate these results and further examine the influence of a number of procedural variables when working with children who have early emergent repertoires of DRR. As will be discussed further in Chapter 6, future research is needed to systematically explore the influence of selection-based rather than topographical responding when working with individuals at such an early level of language skills. Further work is also needed to investigate the extent to which training in the familiar (animal) context might

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generalize to other specific contexts as well as to more general MTS contexts. For example, assuming that the current phenomenon is not very rare and that several further participants with similar repertoires to that of the participants in the current studies could be tested, several questions concerning generalization might be investigated. One such is whether generalization to an intermediate context might be seen. For instance, one could employ a protocol in which the instructions for the animal context were provided at the start of each session but neutral instructions used on each task. A second is whether generalization might result from sufficient time training in the animal context. A third is the extent to which training in a variety of different thematic contexts (e.g., animals, vehicles, foods) might be beneficial.

A related area for future work could involve examining the effectiveness of particular contexts as a foundation for training relational responding skills when they are absent. Such work could involve recruitment of participants as yet unable to demonstrate combinatorial or perhaps even mutual entailment in any context. Subsequent research could examine the efficacy of different contexts for establishing such repertoires. Working with the already ubiquitous animal context might have obvious advantages in this respect. However it could be theoretically and practically informative to compare the utility of several contextual variations in this regard, using between- as well as within-participant research methodologies to do so.

There is much work yet to be done to determine the most efficacious procedures for assessing very early derived relational responding repertoires. However, the work in this chapter provides important evidence supporting the supposition made by RFT that DRR is a contextually controlled repertoire that develops through a history of multiple exemplar training. It also highlights the need to do a careful assessment of such repertoires prior to beginning training, and resulted in the development of the TARPA to allow for multiple stimulus types and the presentation of different instructional contexts during assessment. In the next chapter, research will be presented that involved training DRR with individuals who were not able to demonstrate derived intraverbals in a frame of coordination when assessed, even with the support of a familiar context and familiar stimuli.

Chapter 6

Training Derived Relational Responding in Frames of Coordination

Training Coordination

As noted in Chapter 4, there is evidence for the effectiveness of MET for establishing relational framing in a pattern of coordination, with auditory-visual (tact/listener) as well as auditory-auditory (intraverbal) stimuli at the mutual entailment level (Allan, Vladescu, Kisamore, Reeve & Sidener, 2014; Greer, Stolfi, Chavez-Brown, & Rivera-Valdes, 2005; Greer, Stolfi & Pistoljevic, 2007; Pérez-González, Garcia-Asenjo, Williams & Carnerero, 2007), and with intraverbal responding using textual stimuli at the level of combinatorial entailment (Walsh, Horgan, May, Dymond & Whelan, 2014). However, to date there has been no empirical evidence for the effectiveness of MET for combinatorially entailed intraverbals using auditory (or vocal) stimuli, and only extremely limited evidence of effectiveness with children who are at a very early developmental level with respect to their language skills. Given the importance of derived relational responding to the flexibility of conversational skills, as described earlier, it is critical to explore training methods that could lead to flexibility and generativity of tact, listener, and intraverbal responding. As noted in Chapter 2, while *derivation* is not identified by behavior analytic curriculum-based assessments as a progress marker, some, such as the VB-MAPP (Sundberg, 2008b) do identify responding that could be interpreted as derived relational responding as important skills. For example the ability to “demonstrate tact to intraverbal transfer... without training” (Sundberg, 2008b, p 33) is a progress marker on the VB-MAPP transition assessment. Unfortunately, there are no protocols available for teaching these types of skills if a student does not demonstrate them spontaneously. Thus one of the aims of the research in this chapter in exploring early emergent DRR was to develop and test such a protocol.

As demonstrated in the studies presented in Chapter 5, the context of the assessment task may have a significant impact on the ability of individuals with early levels of language skills to show existing DRR skills. Given that the focus was to investigate the use of MET for combinatorially entailed derived intraverbals for children who are not yet able to demonstrate even this very early repertoire of derived relational responding, the familiar context of animals and their names and sounds was chosen for training. Two studies will be presented. In the first, a case

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study, training was first conducted using abstract colored stimuli in the animal game context as described in the previous chapter, and then using “real-life” pictures of familiar animals as stimuli. In the second, a multiple baseline study with two participants, real-life stimuli were used for all training and testing.

Study 6.1: Case study of MET for coordination

The first study, which provided the initial exploration of the use of MET for establishing relational framing in patterns of coordination, followed the initial case studies described in the previous chapter (Study 5.1). Based on those results, it was decided to test the effectiveness of MET for derived intraverbals using the animal game context for initial screening as well as baseline and intervention phases, with colored abstract stimuli as described previously.

Methods

Participant and Setting. The single participant in this case study, Larry, age 9 years old at the beginning of the study, had an independent diagnosis of ASD, and was enrolled in a nonpublic school that provided 1:1 and group ABA-based intensive educational services based on an analysis of verbal behavior model of assessment and intervention. This participant was identified by his teachers as a student who was able to quickly learn tact and listener discriminations as well as intraverbals, but whose intraverbal skills were generally described as “rote” in that he rarely demonstrated untaught or unscripted responses. He had achieved all Level 2 mand, tact, listener and intraverbal milestones on the VB-MAPP, indicating an approximate developmental language level of 36 months.

Procedures. Sessions were conducted in a separate room at the center where the participant was enrolled. Sessions lasted from 20-30 minutes each, and were conducted 2-3 times per week, barring absences for illness, school holidays, and so on. All procedures for using the Training and Assessment of Relational Precursors and Abilities (TARPA; Moran, Stewart, McElwee & Ming, 2010, 2014; Moran, Walsh, Stewart, McElwee & Ming, 2015) were followed as described in Chapter 5.

Larry was screened first for combinatorially entailed intraverbals (auditory-auditory relations) with two different modalities: a) train tact (visual-auditory),

derive mutually entailed listener (auditory-visual) and combinatorially entailed intraverbal responding, and b) train listener, derive mutually entailed tact and combinatorially entailed intraverbal responding. During screening, only A-B relations were tested for mutual entailment; during subsequent phases, both A-B and C-B relations were tested for mutual entailment prior to testing A-C relations for combinatorial entailment (see Figure 6.1).

During baseline sessions, no training was provided for A-C relations. During intervention, following failure to demonstrate combinatorial entailment, the A-C relations were directly trained using the same procedures as for training A-B and C-B relations.

As discussed below, due to inconsistent performance in multiple exemplar training on the iPad, Larry was also subsequently assessed using tabletop testing procedures with abstract and with real life stimuli. Tabletop testing was conducted using laminated picture cards of the same stimuli used in the TARPA program (see Appendix B), and with laminated picture cards of real animals (e.g., a lion and a dog). With the real life stimuli, participants were trained in the “name” of the animal using common names (e.g., “Joe”); Larry could already identify the sounds the animals made, so while these were tested to ensure he reliably responded to instructions with both the taught name and the animal sound, the conditional discriminations involving animal sounds did not need to be trained.

Inter-observer agreement. Sessions were conducted by the author at the school where the participant was enrolled. Data on all iPad-based trials were collected automatically by the TARPA program. In addition, the experimenter manually tracked whether or not each level of the program was passed or failed to ensure the appropriate progression of training and testing in a session. Manually tracked data for all test sessions were compared to electronic data files, with 100% agreement. During tabletop testing, a second observer (the participant’s instructor at the school) sat behind the experimenter and participant during all sessions and collected data on correct and incorrect responses; inter-observer agreement was 100%.

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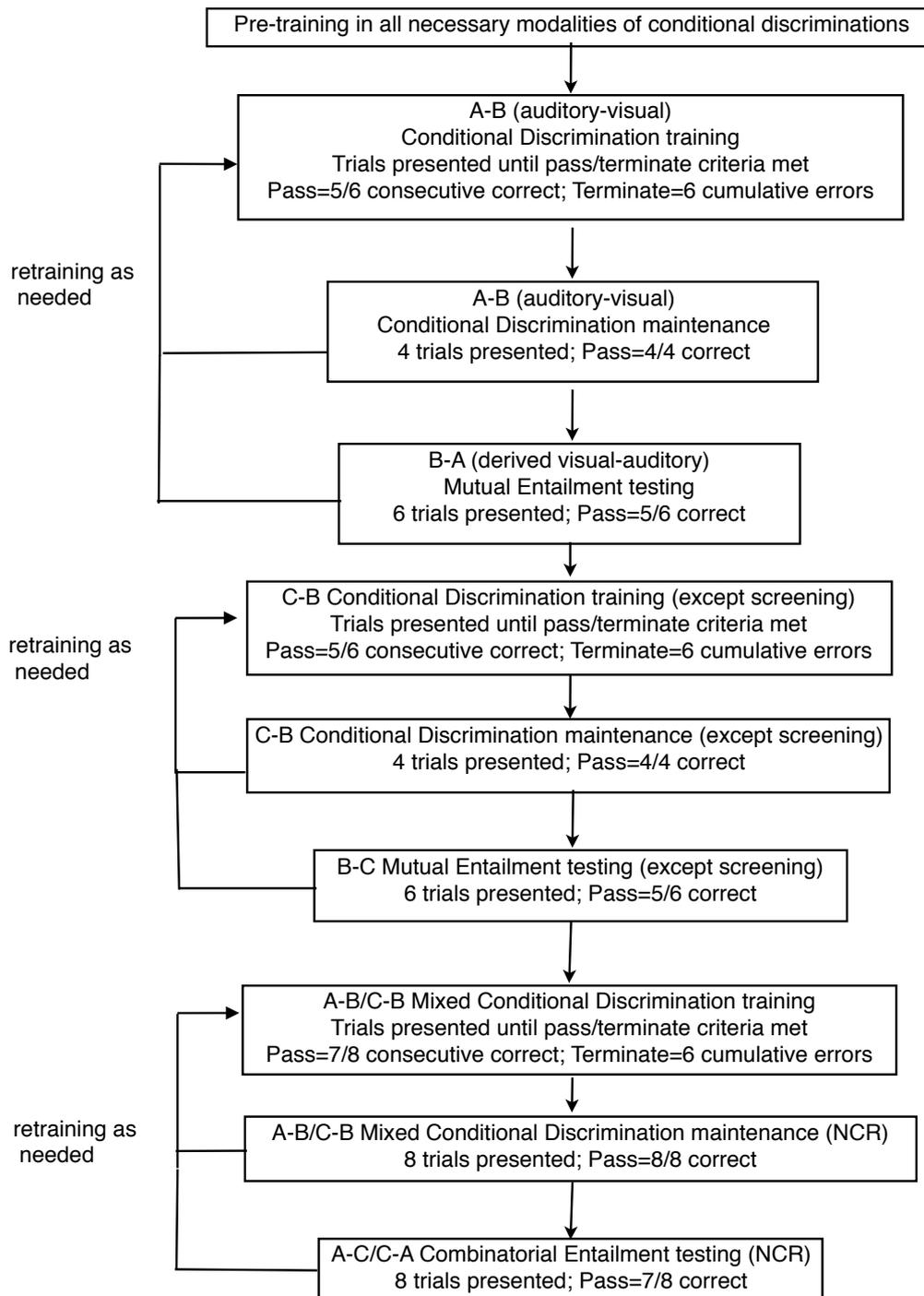


Figure 6.1. Sequence of conditional discrimination training, maintenance testing, and mutual/combinatorial entailment testing.

Results and Discussion

Results of combinatorial entailment testing are shown in Figure 6.2. Larry failed initial screening for combinatorially entailed intraverbal responding both when the baseline relations were trained as tacts and when trained as listener responses. Training proceeded with four additional stimulus sets, with Larry proceeding quickly through training in baseline listener discriminations (A-B and C-B) and passing every test of mutually entailed tacting (B-A and B-C); an average of only 49 training trials were required for baseline listener discriminations in each stimulus set (range 30-60) prior to combinatorial entailment testing, indicating a pattern of progressing at close to 100% in all training sessions and completing testing on each stimulus set in one to two sessions. Larry failed combinatorial entailment tests with each of these four additional stimulus sets. Intervention with multiple exemplar training on the A-C and C-A relations began using the final stimulus set on which the combinatorial entailment test had been failed. Larry was unable to maintain A-C/C-A conditional discriminations in the absence of computer-delivered reinforcement, despite 210 direct A-C/C-A training trials over 10 sessions. At this point, additional testing was conducted with a new set of auditory-auditory relations, (which did not have any associated tact or listener relations) to determine if Larry a) could retain auditory-auditory conditional discriminations when those were presented in isolation and b) if Larry could demonstrate mutual entailment with auditory-auditory relations. It was hypothesized that if either of these skills were lacking then that might affect the ease of learning as well as that of subsequently deriving such relations in the other tests. Following 77 training trials, Larry was able to maintain the conditional discriminations in the absence of iPad-delivered reinforcement. Larry then failed an initial test of mutual entailment, was retrained quickly (14 trials), and then passed the second test for auditory-auditory mutual entailment.

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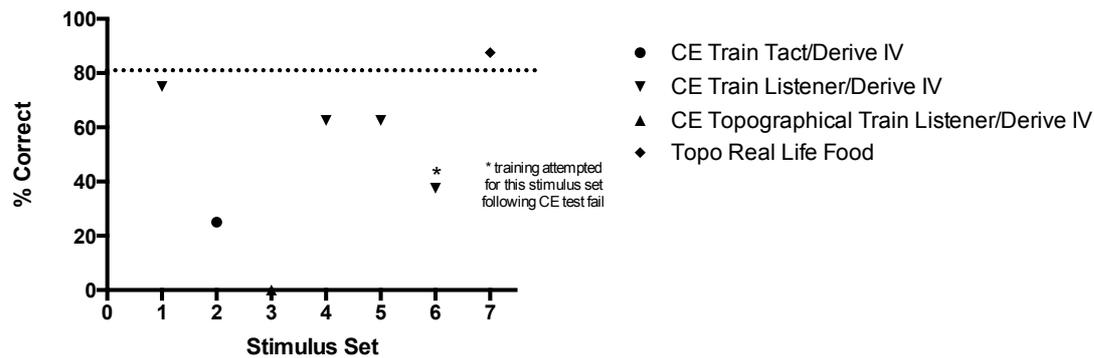


Figure 6.2. Results for Larry: Percentage correct in final (i.e. first or second in the case of a pass, or second in the case of a failed test) combinatorial entailment tests for each stimulus set. Pass is indicated as 7/8 correct. Chance responding based on a comparison array of 2 would be 50% correct.

At this point, the decision was made to try training relations using discrete trial procedures at the table, using “real life” pictures of familiar animals as stimuli, which only required one new trained relation. Larry failed tests of combinatorial entailment with both trained tact and trained listener relations. Throughout training, previous taught responses (e.g., tacting the animals by their type, e.g., “Lion” rather than the name given; repeating the sounds the animals make rather than responding with their names) interfered with maintenance of trained relations, as did difficulty with maintaining motivation and attending behavior. After seven sessions, it was decided to try a novel set of real life stimuli that involved a different set of relations: the picture of the animal (e.g., a lion), the spoken word for the type of animal (“lion”) and the spoken word for a food that the animal “liked” (e.g., “ice cream”). With this set of stimuli, Larry quickly learned the baseline relations (42 total training trials in one session), and although he failed the first test of combinatorial entailment, he passed the second. Subsequently, training proceeded with abstract stimuli in tabletop discrete trial sessions, using a familiar name for the abstract stimuli (e.g., “Mary” rather than “glag”) to see if the less familiar auditory stimuli might be impacting Larry’s performance. However, motivation and attending proved difficult to maintain, and after four sessions the decision was made to discontinue further testing, based on Larry’s demonstrated skills and the significant time that Larry had already spent in various testing sessions.

The results highlighted the difficulty that children with autism may have with selection-based responding vs topographical responding, as well as the impact of the type of stimuli on their demonstration of derived relations. For Larry, testing with topographical responding and familiar stimuli allowed him to demonstrate combinatorially entailed intraverbal responding, whereas either the less familiar stimuli or the use of selection-based responding interfered with this performance; anecdotally, similar results were also obtained with another student with whom screening had been initiated. Which of these variables was the critical one in terms of Larry's performance cannot be ascertained given the uncontrolled nature of this case study. As the primary purpose of the line of inquiry in this chapter was to investigate methods of multiple exemplar training to train derived relational responding when that skill is absent, these issues were not further examined with Larry (however, see Chapter 5 for studies examining the effect of context as well as stimulus type). Instead, it was determined that for the subsequent study of MET, derivation testing and any subsequent training would use real life familiar stimuli with a single new trained relation, and all selection-based responding would also include the requirement to respond vocally prior to selection.

Study 6.2: Testing a MET intervention for coordination

This study followed the initial case study on MET described above as well as the studies on the influence of the familiarity of both context and stimulus type with respect to children's abilities to demonstrate derived relational responding as described in Chapter 5. The aim was to train repertoires of derived relational responding when those skills were clearly absent, specifically examining MET for derived intraverbal responding in the context of a game about animals and their names and sounds. In this study, real life stimuli with only one new trained relation were used throughout, as this had been determined to be a particularly supportive context for the emergence of derived relational responding.

Methods

Participants and Setting. As in previous studies, participants were students with independent diagnoses of ASD, who were enrolled in a nonpublic school that

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provided 1:1 and group ABA-based intensive educational services based on an analysis of verbal behavior model of assessment and intervention. Participants were identified by their teachers as students who were able to quickly learn tact and listener discriminations as well as intraverbals, but whose intraverbal skills were generally described as “rote” in that they rarely demonstrated untaught or unscripted responses. Eight children were screened for potential inclusion in this study, with two of those passing tests of combinatorial entailment either in topographical or iPad-based testing within the screening period, and four not being able to learn the necessary conditional discriminations quickly during screening tests. One of the two remaining participants had previously been considered for inclusion in the earlier pilot study on MET, and had failed initial screening tests of combinatorial entailment with colored abstract stimuli using the animal game context prior to that study’s termination.

Lily, age 12 at the beginning of the study, had a Peabody Picture Vocabulary Test (PPVT) age equivalency score of 3-9. Dan, age 14 at the beginning of the study, had a PPVT age equivalency score of 2-5.

Sessions took place in a separate room at the center where the participants were enrolled, and were conducted by the behavior analysts and teachers at the school. Due to participant availability, staff availability, and technical changes to the iPad program over the course of the study, there were several breaks of a few weeks to several months between stimulus sets during baseline and during the initial part of the intervention phase (as described below). When sessions were occurring, they took place two to three times per week, and lasted from 20-30 minutes. The baseline phase and first intervention portion of the study thus took place over the course of approximately 14 months, with the final intervention phase taking place over approximately 3 months for Lily and 6 months for Dan.

Procedures. All procedures for assessing DRR skills using the TARPA program as described in previous studies were followed, using real life pictures of common animals as visual stimuli, common American names as one auditory stimulus, and the sounds the animals make as the second auditory stimulus (see Table 6.1 for examples of stimuli). At first glance, the use of common American

names for animals, rather than teaching more common or "useful" content about animals, might seem unnecessarily contrived. However, this context allowed sufficient control for any previous learning history associated with the stimuli while having the benefit of limiting the number of new conditional discriminations to be learned in each set, and also using a context that is not uncommon in early education—animals in storybooks are usually named, for example.

The order of presentation of specific sets was varied across the participants. Both participants were tested for combinatorially entailed intraverbals (auditory-auditory relations) with two different modalities: a) train tact (visual-auditory), derive mutually entailed listener (auditory-visual) and combinatorially entailed intraverbal responding, and b) train listener, derive mutually entailed tact and combinatorially entailed intraverbal responding. Participants were also tested to ensure they could acquire auditory-auditory conditional discriminations, and were tested using topographical table-top testing for combinatorially entailed intraverbals following conditional discrimination training in the relevant relations. Based on the results of this screening, Lily was subsequently trained and tested using the train listener, derive tact, derive intraverbals format. David was unable to pass tests of mutual entailment in that format, however, and so he was trained and tested using the train tact, derive listener, derive intraverbals format (see Figure 6.3 for the relations trained and tested for Lily and Dan). As noted previously, in both formats the participants were required to emit both listener and tact responses (either trained or derived) for the baseline (A-B/B-A and C-B/B-C) relations prior to testing for derived intraverbals.

A nonconcurrent multiple probe design was planned due to practical considerations as discussed in Chapter 5, with participants pre-assigned to either 2 or 4 baseline sessions prior to the introduction of multiple exemplar training (as recommended by Watson & Workman, 1981). Intervention began with the stimulus set for which tests of combinatorial entailment had been failed during the final baseline session for each participant. Training sessions began with the presentation of the mixed baseline relations (A-B/C-B or B-A/B-C) followed by direct training on the intraverbal relations (A-C/C-A). As will be discussed below, several

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modifications to the training procedures were made, resulting in the final testing protocol involving a sequence of training the AC relations alone, then all relations (A-B/B-A/C-B/B-C/A-C/C-A) mixed together, and then the intraverbal relations (A-C/C-A). Once participants were able to demonstrate the trained A-C/C-A intraverbal relations with iPad delivered reinforcement, they then were required to demonstrate those same relations in the absence of iPad delivered reinforcement. Following successful demonstration of those trained relations, a new stimulus set was presented. If the participant again failed tests of combinatorial entailment with that set, intervention began using that stimulus set. Training on stimulus sets continued until the participants could pass tests of combinatorial entailment with two consecutive novel stimulus sets. Following successful demonstration of derived intraverbal responding using the iPad game, participants were tested again using the same procedures in a tabletop (topographical) format.

Set	A (name) (new)	B (animal) (known)	C (sound) (known)
Set 1	Jack		Roar
	Ted		Ssss
Set 2	Sue		Quack
	Jane		Moo

Table 6.1. Examples of stimulus sets used.

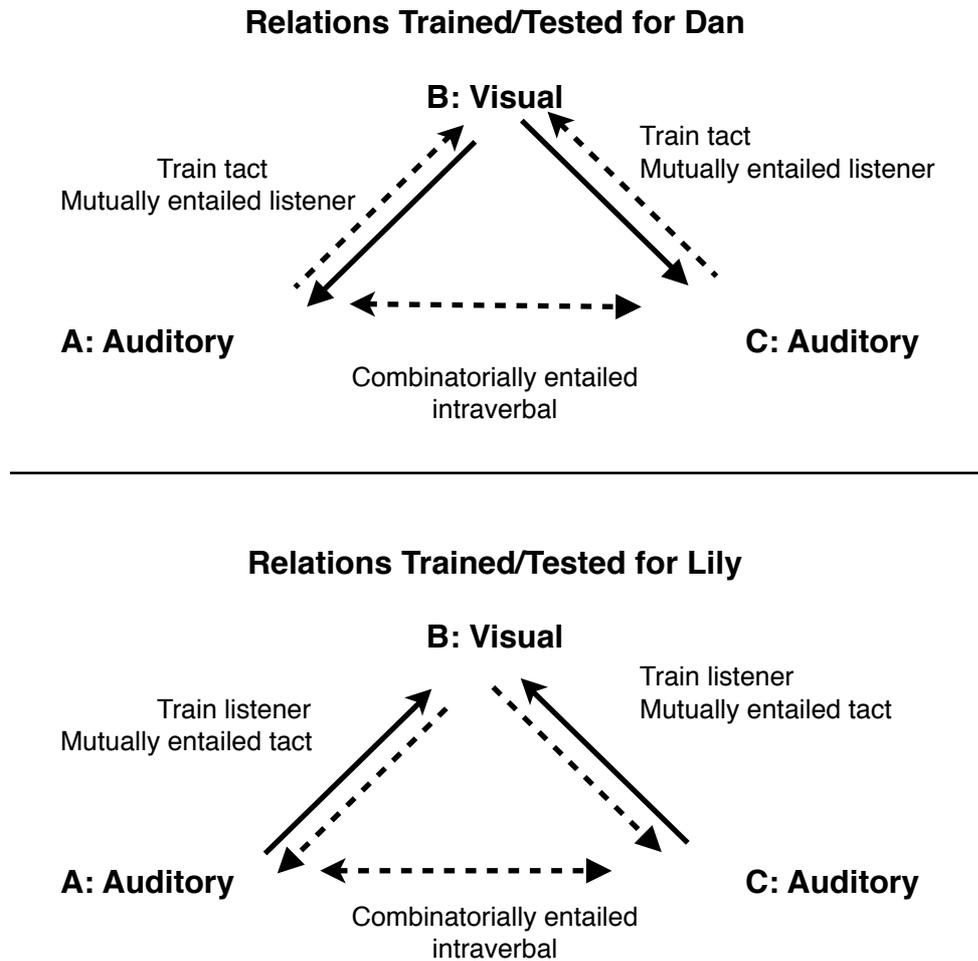


Figure 6.3. Trained and tested stimulus relations for Dan and Lily.

Procedural fidelity and inter-observer agreement. School staff members were trained in the use of the program until they reached 100% fidelity on both training and testing trial types. Probes of sessions were observed in person or via video for procedural fidelity (see Appendix C) for approximately 10% of training sessions and 20% of testing sessions, with probes ranging from 96% to 100% fidelity.

Data on all iPad based trials were collected automatically by the TARPA program. In addition, the experimenters manually tracked whether or not each level of the program was passed or failed to ensure the appropriate progression of training

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and testing in a session. Experimenter error resulted in both participants being tested six times (rather than only two times) on one of the stimulus sets during baseline, and in Lily being trained on a stimulus set in intervention without having previously been tested. Manually tracked data for all test sessions were compared to electronic data files, with 100% agreement. During tabletop testing, a second observer sat behind the experimenter and participant or observed via video, and collected data during 25% of all training and testing sessions; inter-observer agreement was 100%.

Results and Discussion

Results of the final CE test on each stimulus set for both participants are shown in Figure 6.4. Dan failed both baseline combinatorial entailment tests on the TARPA and a topographical test using the train tact/test listener/test intraverbal format. He was not able to progress past the mutual entailment test using the train listener/derive tact/derive intraverbal format. Following baseline sessions, Dan began intervention on the final stimulus set of baseline (set 4). He was provided with 20 training trials on A-C/C-A relations and successfully passed a test of maintenance. He was subsequently tested on a new stimulus set (set 5), on which he failed the combinatorial entailment (CE) test; on this set he had difficulty both with maintaining trained relations and persisting in the training task, and changes to the intervention protocol were made as will be discussed below.

For Lily, training began after failing CE tests in baseline on four stimulus sets using the train listener/derive tact/derive intraverbal format on the TARPA, one set in topographical testing, and one set using the train tact/derive listener/derive intraverbal format on the TARPA (i.e. six stimulus sets in total). It was on the sixth set (the first to be trained) that Lily had difficulty with maintaining taught relations and persisting in the training task, and with which variations in training procedures were developed as described below. On this set there were 182 training trials provided over 12 sessions, with several 3-4 week breaks as the program was revised as well as a four month break due to teacher availability. She ultimately passed the maintenance test on trained A-C/C-A relations for that set.

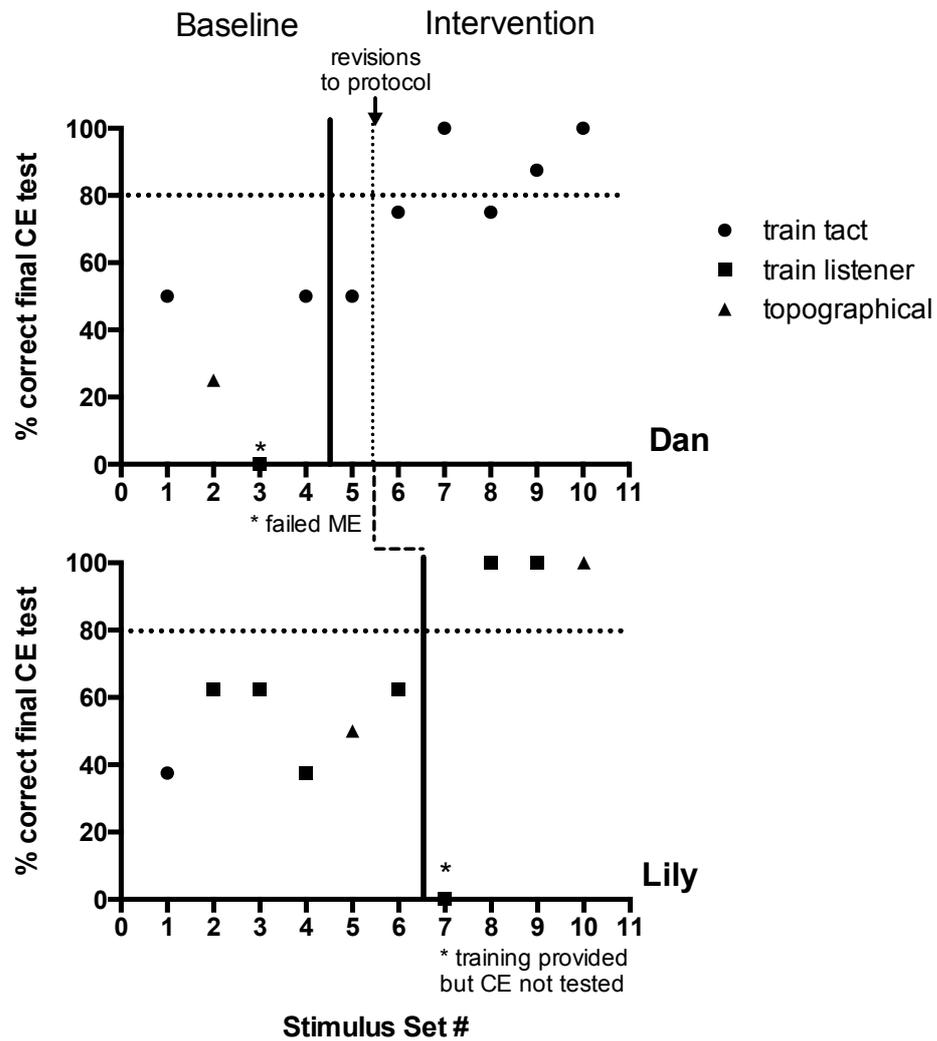


Figure 6.4. Results of multiple exemplar training for Dan and Lily: Percentage correct in final (i.e. first or second in the case of a pass, or second in the case of a failed test) combinatorial entailment tests for each stimulus set. Pass is indicated as 7/8 correct. Chance responding based on a comparison array of 2 would be 50% correct.

Since both participants had difficulty maintaining trained A-C/C-A relations following the initial intervention format, which presented these relations in isolation, several changes were made to the intervention. The new intervention began with a new stimulus set and a new intervention sequence for both participants, in which

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training was provided on all previously trained/tested relations; thus, training included A-B/B-A, C-B/B-C, and A-C/C-A relations. Both participants, however, had difficulty persisting with this training task, and so a second revision was made. First participants were trained on just the A-C relations, then on all the mixed relations, and then on A-C/C-A relations. With this revision, both participants successfully completed the training tasks. Dan was subsequently tested on a new stimulus set (6), on which he failed the CE test (although his performance was improved from baseline) and was provided with 65 training trials over 3 sessions using the final training protocol. On the next stimulus set (7), Dan immediately passed the CE test; on the subsequent set (8), he again failed the CE test and was provided with 145 training trials over 7 sessions. He subsequently passed the CE test with the next two novel sets of stimuli. Conditional discrimination training was then begun for a topographical test with a novel set of stimuli; at the time of this writing, Dan had completed several training sessions but had not yet passed the maintenance test of the mixed trained tact (B-A, B-C) relations, which is necessary prior to CE testing.

For Lily, with the first stimulus set using the new training protocol, experimenter error resulted in her being trained on a novel set (7) using the new training protocol without having been tested for derived relations on that set. On this set, 88 training trials were provided over 6 sessions. On the next set (8), Lily passed the CE test, and was tested again on a novel set (9), which she also passed. A topographical test was conducted using another set (10), and she immediately passed the combinatorial entailment test.

While very preliminary, the results of this study show promise for training a generalized repertoire of deriving combinatorially entailed intraverbals, and this is the first study to demonstrate such results with auditory/vocal stimuli. This is also the first study to examine a format for testing and training derived intraverbals following tact and listener training using a natural language context. These results therefore lend support to the supposition made by RFT that derived relational responding is a learned operant that is established through a history of training in relational patterns of responding.

There are many limitations of this study, including the number of participants, modifications made during the initial phase of intervention to the training protocol, and the lengthy breaks that resulted from the need to make changes to the program as well as due to participant and teacher availability. Additionally, since a nonconcurrent design was planned but Dan did not respond immediately to the intervention condition, both participants were exposed to the new training at about the same point in time. Moreover, both participants first passed a CE test on the seventh stimulus set for which testing was done (although this was a different set for each participant) and so simple exposure to multiple stimulus sets cannot be ruled out as a possible explanation for both participants' results with respect to passing that CE test. Lily's clear and immediate response to the intervention, along with Dan's improved performance immediately following changes to the training protocol, makes this possible explanation less likely but it is nonetheless a concern. Furthermore, two different formats of training baseline conditional discriminations were used, with Dan learning the initial discriminations in a tact format and Lily learning the initial discriminations in a listener format. Each participant received the same training intervention (which was comprised of tact, listener, and intraverbal training in all the relations), and as mutual entailment was tested, each participant was required both to tact and respond as a listener for all baseline relations (A-B/B-A and C-B/B-C). However, the fact that combinatorial entailment was tested under a different baseline training circumstance for each participant further weakens the experimental control that would have otherwise be demonstrated by the originally planned multiple baseline design of the study. Nonetheless, this also suggests that the intervention has promise regardless of which format is used for baseline conditional discrimination training. Future studies should replicate this work across a larger number of participants, and counterbalance the use of either tact or listener training for baseline relations to compare the two.

General Discussion

The two studies in this chapter represent the first attempts to establish a repertoire of combinatorially entailed derived intraverbal responding with children

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who do not yet have that repertoire even in a very supportive context, using auditory stimuli as well as vocal responding. While very preliminary, these studies resulted in the development of a training protocol that shows strong promise for training intraverbal DRR skills. As noted in Chapters 3 and 4, there have been a number of studies that have used individuals' existing DRR repertoires to efficiently teach new content, including intraverbal responding, and there have been some demonstrations of MET for training derived intraverbals at a mutually entailed level. However, as yet there have been none that train the derivation of combinatorially entailed intraverbals using auditory/vocal stimuli and there has been very little evidence for the effectiveness of MET for establishing DRR with individuals with very early language skills. Intraverbal skills are critical to conversation and academic abilities, but a taught intraverbal repertoire is wholly insufficient for responding to the rapidly changing verbal stimuli present in a typical social or academic environment. Without a repertoire of *derived* intraverbal responding, individuals may only be able to rote respond to specific questions; such is the case for many students with autism. With the development of teaching protocols that focus on the development of repertoires related to derived relational responding, rather than simply teaching additional content, we will be able to more systematically address deficits in generalized responding such as “demonstrat[ing] transfer between the verbal operants without training” (Sundberg, 2008b, p33).

One interesting finding to come out of the screening tests for participants was the possibility that students could fail the CE tests on the TARPA and yet pass the same tests when presented topographically. This, along with the issues already noted in previous studies in Chapter 5 with participants selecting one auditory stimulus but vocally responding with the other, highlights the need for further studies of topographical vs selection-based responding. Particularly in the context of developing computer-based educational programming for early language learners, this is a critical area to examine, because the potential advantages of computer-based training may be rendered moot for this population if selection-based response requirements mask students' abilities and/or make training derivation skills significantly more difficult. The few existing studies of derivation with selection-

based vs topographical responding have shown contradictory effects. Polson, Grabavac and Parsons (1997) and Polson and Parsons (2000) found that the typically developing adult participants in their studies were less likely to demonstrate symmetry using typing as a topographical intraverbal response form than when selecting written words. On the other hand, working with individuals with developmental disabilities, Sundberg and Sundberg (1990) as well as Wraikat, Sundberg and Michael (1991) found that the use of sign language as a topographical response form resulted in faster acquisition of tacts and intraverbal responses as well as a greater likelihood of demonstrating stimulus equivalence as compared to selection of abstract symbols. The different outcomes between these two sets of studies may be due to the pre-existing language skills of participants (typically developing adults vs individuals with developmental disabilities), the topographical response form chosen (typing vs signing), or the meaningfulness of stimuli used for selection-based responding (written English words vs abstract visual stimuli), and these are all issues to explore. Moreover, there has been no study of the likelihood of demonstrating derived intraverbal responding that compares selection of auditory stimuli with production of vocal words.

Another interesting finding, yet also a limitation, of the studies in this chapter was the difficulty in identifying participants for whom the training would be relevant. A number of students that were initially identified as potential candidates were able to pass CE tests after a few exposures to testing under baseline conditions, as has been found in many stimulus equivalence studies (e.g., Lazar, Davis-Lang, & Sanchez, 1984; Sidman, Kirk, & Willson-Morris, 1985). This finding might indicate that such students need more exposure to the opportunity to derive relations (rather than continued direct teaching), and that such opportunities might in and of themselves strengthen an existing but fragile repertoire of DRR. Future research might explore the utility of exposure to derivation tests across multiple contexts with respect to establishing a more robust and generalized repertoire of DRR. On the other hand, a number of students identified for potential participation in this study were not able to learn new conditional discriminations quickly enough for us to feel that it would be ethical to use their school time participating in the study. This

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requirement was, however, somewhat arbitrary, and future research might explore the relation between trials to criterion when learning a new conditional discrimination and the ability to learn and/or demonstrate derivation. Previous work (e.g., O'Connor, Rafferty, D. Barnes-Holmes & Y. Barnes-Holmes, 2009) has found that level of verbal skill is negatively correlated with number of trials to criterion prior to demonstrating equivalence. Identifying a fluency criterion with respect to acquisition of novel conditional discriminations that indicated the likelihood of being able to learn DRR skills would be very valuable. Such a criterion could be used as a progress marker for shifting the focus of programs from learning new vocabulary (in the sense of taught tact, listener and intraverbal responses) to also including programs for learning and capitalizing on DRR skills.

As noted above, much work is also needed to replicate the results of these studies with additional participants and with better experimental control. Future work is also needed to determine the utility of training procedures such as those used in these studies with respect to generalization of DRR skills to new contexts. While the participants in these studies appeared able to generalize from the iPad based task to topographical responding in a table top task, only one context was tested. Additional contexts need to be examined, as in the initial pilot study described in this chapter for example, which also asked the participant to identify what food an animal liked. Similar contexts could include the types of toys that children like, where animals live, and so on. It is also important to consider to what extent the acquisition of the DRR skills established in this study might affect other important skills sets—will the acquisition of this repertoire result in more varied responses in conversation? Will it result in an increased rate of acquisition of academic tasks or other language skills? In theory, a robust repertoire of deriving intraverbal responses in frames of coordination should make a significant difference in an individual's verbal skills in a wide range of contexts. To what extent this occurs as a result of an intervention to teach the derivation of intraverbals in an instructional context such as that studied here, is an empirical question yet to be answered (although of course the instructional task examined here should be just one component of a comprehensive intervention program).

In sum, while there is much work to be done, the protocol developed in these studies adds to the limited literature on how to establish DRR abilities when they are absent, particularly with respect to intraverbal skills. These studies provide a stepping stone for further work that is in line with Rehfeldt's (2010, 2011) recommendations for pursuing translational research on DRR, as well as contributing to the synthesis of RFT and Skinnerian verbal behavior. Moreover, they focus on a socially valid activity, and lay the foundation for future research on derived intraverbal responding in a variety of critical social and academic contexts.

Chapter 7:
A Review of Research into Difference Relations

The material in this chapter has been accepted for publication with revisions, as:
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Journal of Applied Behavior Analysis.

Difference Relations

*One of these things is not like the others,
One of these things just doesn't belong.
Can you tell which thing is not like the others
By the time I finish my song?
—Sesame Street (1970)*

Behavior analysts charged with developing individualized intervention programs for clients with developmental disabilities, including autism spectrum disorders (ASD), have long utilized the concept of identifying and teaching behavioral cusps (Rosales-Ruiz & Baer, 1997; Bosch & Fuqua, 2001) and pivotal behaviors (Koegel, O'Dell, & Koegel, 1987). A behavioral cusp has been defined as any behavior change that allows an organism to come into contact with new contingencies that have broad and significant effects with respect to establishing and maintaining other new behaviors (Rosales-Ruiz & Baer, 1997). One such behavior change occurs when individuals learn to make generalized same/different judgments (McIlvane et al., 2011). However, whereas coordination (sameness, matching) has been studied more extensively, there appears to be a significant gap in both behavior analytic research and educational programs with regard to relations of difference at both non-arbitrary and arbitrary levels of relational responding. Thus, in this chapter, a wide range of research is reviewed with respect to responding in a relation of difference, from a variety of domains including: comparative psychology, experimental and translational behavior analysis, Skinnerian verbal behavior, and Relational Frame Theory (RFT; Hayes, Barnes-Holmes & Roche, 2001). The review begins with research into the earliest forms of responding to relations of difference, including perception of difference and oddity responding, and covers up until recent studies focused on establishing relational frames of distinction with highly abstract stimuli. Within each of these repertoires, suggestions are made for future research and potential methods are described for teaching skills related to responding in accordance with relations of difference. Some of these suggestions form the basis of

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the research presented in the next chapter, in which derived relational responding in accordance with combined frames of coordination and distinction is explored.

Being able to identify stimuli as being different from one another (vs the same) is a skill that within the cognitive developmental, comparative and educational psychology literature is considered so important as to be seen as fundamental to cognition (e.g., Thompson & Oden, 1996; Addyman & Mareschal, 2010). The ability to use abstract language concepts, particularly “sameness/difference,” to classify the relations among objects and events has been described as being the “hallmark of human intelligence” (Blaisdell & Cook, 2005)—the “very keel and background of our thinking” (James, 1981/1890, p 434). One of the main lines of research in comparative psychology for decades (e.g., Nissen, Blum, & Blum, 1948) has been to determine whether nonhuman subjects are capable of same/different responding, long considered to be evidence of “conceptually-mediated” behavior. Finally, within educational psychology research, identifying similarities and differences between stimuli or concepts has been highlighted as having a particularly powerful impact on student achievement by Marzano, Pickering and Pollock (2001) in their meta-analysis of research-based teaching strategies, and indeed they describe this skill as “basic to human thought...the ‘core’ of all learning” (2001, p. 14).

Same/different responding features prominently in academic curricula. At the preschool level (e.g., see California Department of Education, 2008), important milestones at the 48 month level include showing interest in how people are the same and different, and describing simple relations between objects such as pointing to pictures of two different animals and saying that they are “different.” At the 60 month level, preschoolers are expected to be able to describe differences between items based on informational text, such as by “communicat[ing] important differences of jet airplanes and propeller planes after being read a story about airplanes and airports” (2008, p. 68). Marzano and colleagues (2001) note that identifying similarities and differences is the foundation of numerous effective instructional activities at all academic levels and across subjects involving comparing, classifying, creating metaphors and creating analogies. Identification of similarities and differences, including comparing/contrasting, are also clearly

identified academic standards across multiple grades and subjects within the widely adopted Common Core curriculum (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

In light of the emphasis on both sameness and *difference* within the educational literature more broadly, it is somewhat surprising that there is relatively little explicit emphasis on identifying difference skills in behavior analytic educational programs for children with autism. Programs based on an analysis of verbal behavior (e.g., Sundberg 2008b; Partington 2006) place little to no emphasis on identifying difference, considering the responses involved to be too complex to be developmentally appropriate for early language intervention programs (e.g., autoclitics, see Sundberg, 2004). More traditional programs based on applied behavior analysis (ABA) do include some difference programs (e.g., Leaf & McEachin, 1999; Maurice, Green, & Luce, 1996; Center for Autism and Related Disorders, 2013), which vary in comprehensiveness. The most detailed of these includes a number of lessons sequenced from matching same/different through identifying items as being the same or different and identifying how two presented items are the same or different (i.e., in terms of their attributes or categories) (Center for Autism and Related Disorders, 2013). However, even these programs provide a relatively limited task analysis and training procedures, given the potential range from very early to very complex same/different skills.

There is certainly an appropriate emphasis and sequenced curricula within intervention programs (and in the literature) on the importance of teaching “sameness”, and it might be argued that when teaching “same”, we are inherently also teaching “different”, as the two concepts cannot exist except in contrast to one another (i.e., if something is not “same”, it is necessarily “different”, and vice versa). However, there are a number of reasons why focusing on difference relations per se is important. First, while it might seem logical that if a person can respond to same then they can also respond to different, empirical evidence suggests that this is not the case. As discussed further below, research with individuals with developmental disabilities has demonstrated that individuals capable of identity matching are not necessarily capable of oddity responding, and vice versa (e.g., Soraci, et al., 1987;

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Mackay, Soraci, Carlin, Dennis and Strawbridge, 2002). A similar argument can be made in response to the suggestion that teaching other types of relations (e.g., comparison) might implicitly teach difference relations by virtue of the fact that a difference along any relational dimension (e.g., being more than something) automatically implies a difference in absolute terms. While the latter might be true in a logical sense, this does not imply that it would be true at the psychological or behavioral level. Responding in accordance with difference relations is a particular pattern of behavior that likely requires particular contingencies for its development (e.g., see Hayes, Fox, et al. 2001).

Second, explicitly training the relation of difference as a contrast to same necessitates the use of contextual control in order to differentiate the two. The teacher must use contextual cues such as “same” (or “match”) and “different” (or “not same”) to differentiate the tasks. Use of contextual control such as this means that not only is the student learning a new relation, but that they can also be taught, by switching between the two cues, to come under contextual control of more than one relation within the same task, which can be used to assess and train flexibility of responding. Establishing contextual control is also necessary as the foundation for the development of further skills at more complex levels including responding to same versus different along alternative physical dimensions (shape, color, size etc.), as well as abstraction of contextual control from the realm of concrete or physical stimuli to that of abstract sameness and difference (as will be discussed later). Both of these skills in turn feed into the critical higher order skill of categorization (e.g., being able to respond to category related questions such as “How is a dog like a cat?” or “How is a cow different from a bird?”). Hence, by not deliberately bringing behavior under the control of cues for difference at an early age and training discrimination between difference and same, we neglect to establish a foundation for critically important repertoires.

No ABA programs for teaching difference responding describe a comprehensive and conceptually systematic curriculum for these skills that is rooted in empirical behavior analytic research, as opposed to clinical experience or traditional preschool educational programming. Thus, there is little to guide the

practitioner when faced with students who lack these skills and do not progress with traditional lesson plans. This may be because difference responding has been viewed as a variety of distinct types of skills (e.g., visual performance, listener responses, complex conditional discriminations, autoclitic tacts, multiply controlled intraverbal responding) depending on what the specific response is and depending on the theoretical orientation of the program. However, a relatively coherent approach may be provided by approaching responding to similarities or differences between events fundamentally as *relational* responding, and taking this view opens up a conceptually systematic path to curriculum development (including even early developmental levels) that is otherwise less clear.

Relational Responding

In this review, RFT will be used as the framework for discussing the work that has been done on same/different relations. When viewing same/different responding as a relational response, RFT makes a key distinction between arbitrary and non-arbitrary relational responding, as discussed in Chapter 3. This distinction is critical to the structure of this chapter, and hence will be reviewed briefly. At the non-arbitrary level, relational responding in accordance with difference (for example, *oddity* responding) involves selecting an item that is physically different from a sample. Which pattern is required in a given circumstance will be determined by a contextual cue. For example, with respect to responding to a relation of difference, a contextual cue such as “different” or “not the same” or “doesn’t belong” would indicate that the correct response would be to select an item that is different from a sample, rather than the same. Despite the fact that contextual control can determine which physical relation is appropriate, in the case of non-arbitrary relational responding, the response is still fundamentally dependent on physical characteristics of the related stimuli.

Arbitrary relational responding in accordance with difference (distinction) involves responding to two stimuli under control of a cue for a pattern of distinction that can be completely independent of the physical properties of the stimuli. Typically, such cues signal the stimuli involved as being different along some

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socially or conventionally defined dimension, or coherent with criteria that are not immediately available for inspection in the same way that non-arbitrary relations are. For example, when discussing how other children in her class compare and contrast in terms of their likes and dislikes, a child might learn that Johnny likes the same food as Susie, but different food from Alan. In such a case, there need be no immediately physically obvious dimensions of the individuals being related that allow the child to relate other children in her class in this way; instead, she relates them in particular ways based on the arbitrary cues “same” and “different” and can derive new relations accordingly. For example, having learned that Johnny likes the same food as Susie and different food from Alan, then she might derive that Susie and Alan like different food from each other.

In this chapter, the focus will be on difference relations and both non-arbitrary and arbitrary versions will be considered. Much of the work conducted has been with respect to non-arbitrary same/different relational responding, which has been studied in the comparative literature with a variety of species. Early developing perceptual precursors (such as orienting towards stimuli that are different from those previously seen) and early types of non-arbitrary relational responding—identity and oddity—have also been well studied with humans. Thus the literature will be reviewed from comparative psychology as well as traditional ABA and RFT, and research on responding across the continuum of non-arbitrary and arbitrary relations will be examined.

Topographies of relational responding

A variety of different topographies have been studied in empirical research on relational responding. Responses that have been studied include (a) matching stimulus pairs on the basis of the relation they exemplify (e.g., matching the pair A-A [same] to the pair B-B [same] rather than C-D [different]); (b) selecting stimuli under the contextual control of cues for the relation (e.g., selecting an item that is the same or different from a sample under the control of the textual or spoken stimuli “same” or “different”, respectively); and (c) producing/selecting the names of relations in response to stimulus pairs or sets (e.g., producing the vocal responses “same” or

“different” or selecting one of the textual stimuli “same” or “different” in response to a pair of stimulus objects).

These different topographies of responding are similar to the extent that they constitute contextually-controlled relational responses. However, some theories would make substantial distinctions between them, and various terms are used depending on the orientation of the research. Responses involving the matching of stimulus pairs based on the relation each pair exemplifies is almost exclusively termed “relational matching” (Smirnova, 2015; Thompson & Oden, 1996), although such responses may also be referred to as analogical responding (e.g., Quah, 2014; Smirnova, 2015). Selecting stimuli under the control of a contextual cue is most frequently discussed as a complex conditional discrimination, referencing the specific relation (such as “conditional same/different discrimination”; Thompson & Oden, 1996), although earlier research may refer to this as “oddity matching” (e.g., Nevin, 1966). In clinical application, such responses are generally considered under the broader category of “receptive discrimination”, such as in programs for “Same/Different: Receptive” (Center for Autism and Related Disorders, 2013). Responses that involve producing/selecting the names of relations in response to pairs or sets of stimuli have been variously termed “selecting the cue” (vs “selecting the sample”) (Gil, Luciano, Ruiz, & Valdivia-Salas, 2012), “relational tacting” (Quah 2013), “autoclitic tacts” (Howard & Rice, 1988), and “same/different classification” (e.g., Mercado, Killebrew, Pack, Mácha, & Herman, 2000). All these terms have their own merits and drawbacks, and a full discussion of the conceptual systematicity of various terms is beyond the scope of this review. Nonetheless, to provide a clear organization to this review, a consistent set of terms is needed, regardless of the theoretical orientation of the paper being discussed, and for simplicity’s sake, terms have been chosen that may be more familiar to clinicians, including terms based on Skinnerian verbal operants. Thus the term *relational matching* will be used to describe pair matching on the basis of the relation exemplified by the pairs involved (e.g., matching AB [different] with XY [different] rather than ZZ [same]). The selection of comparison stimuli in a MTS format, under the control of a specific relational cue (such as “find different”) will be referred to as *relational listener*

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discriminations. Finally, the production/selection of the name of a relation (e.g., “different”) in response to two stimuli in a pair (e.g., two physically dissimilar stimuli) will be referred to as *relational tacting*, whether the response to a pair/set of stimuli is topographical (such as saying “different”) or selection-based (such as selecting the textual stimulus “different”).

Research on same/different relational responding has been carried out from a variety of theoretical orientations, but as noted, the review in this chapter will be structured around core elements of relational responding as identified by RFT. It will thus begin with early non-arbitrary relational responding and proceed to arbitrary (arbitrarily applicable) relational responding. Each section will provide recommendations for future applied research as well as discuss implications of the existing literature with respect to clinical practice.

Non-Arbitrary Relational Responding

As noted above, non-arbitrary responding in accordance with a relation of coordination or distinction can include matching pairs of stimuli on the basis of the relations involved (e.g., matching two cows to two dogs rather than to a cat and horse) (relational matching); or selecting an item that is the same or different from a sample (relational listener discriminations); or producing/selecting the name of a relation in response to items either physically different or the same as each other (relational tacting). Furthermore, the experimental literature would suggest that prior to being able to do any of these types of non-arbitrary relational responding, organisms must first be able to discriminate between relevant stimuli and learn to respond in accordance with a relation of physical difference, referred to as “oddity” matching. The literature will be reviewed related to these early types of responding in relations of distinction as follows: a) perception of sameness/difference, including non-arbitrary difference responding based on history of training rather than based on contextual cues (“oddity matching” or “non-matching to sample”); b) non-arbitrary relational matching; c) non-arbitrary contextually controlled relational listener discriminations; and d) non-arbitrary relational tacting.

Visual perceptual responses and oddity matching

Visual discrimination is important for attention and learning involving visual stimuli; individuals must be able to *observe* the relevant features of stimuli and the relations between them, presented in such a way as to be able to differentially respond given the requirements of a particular task (Soraci, Carlin & Bray, 1992; Carlin, Soraci Jr, and Strawbridge, 2003). As it happens, research using visual search tasks (e.g., see Carlin, Soraci Jr., & Strawbridge, 2003) has suggested that people with developmental delays may be less sensitive to differences between stimuli across a variety of dimensions. Given this possibility, precise assessment and robust training procedures are essential.

At the very earliest level, researchers from a cognitive perspective have examined the ability of a variety of non-human species as well as of human infants to perceive physical relations of difference versus sameness. For example, preference-for-novelty research has found that sensitivity to physical relations of same and different can be seen in human infants as early as 7 to 8 months (Tyrrell, Stauffer, & Snowman, 1991; Addyman & Mareschal, 2010) and in infant chimpanzees as early as 9 months (Oden, Thompson, & Premack, 1990), but not earlier. Such results indicate that discrimination of relations of sameness versus difference is a repertoire that starts to be shaped up early on; ideally, then such a repertoire should be able to be taught to individuals at fairly young developmental ages. Perceptual and cognitive researchers of both human and animal behavior as well as behavior analysts (e.g., House, 1964; Lipsitt & Serunian, 1963; Scott, 1964; Zentall, Edwards, Moore, & Hogan, 1981; Dixon & Dixon, 1978; Dube, McIlvane, & Green, 1992), have long studied the processes involved in learning the earliest forms of responding in accordance with relations of sameness or difference: oddity and identity matching. We will here review representative samples of this literature, with emphasis on research that is particularly applicable to the development of educational programming.

Responding on the basis of oddity relations has been trained in a variety of non-human species, including pigeons (e.g., Urcuioli, 1977; Lydersen, Perkins, &

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Chairez, 1977; Zentall et al., 1981), corvids (e.g., Wilson, Mackintosh, & Boakes, 1985; Smirnova, Lazareva, & Zorina, 2000), rats (e.g., April, Bruce, & Galizio, 2011), bees (Avarguès-Weber, Dyer, Combe, & Giurfa, 2012), sea lions (e.g., Hille, Dehnhardt, & Mauck, 2006), and various primates (e.g., Davis, Leary, Stevens, & Thompson, 1967). In these studies, the subject is trained to respond in a MTS context in which selecting the comparison stimulus that is different from the sample is reinforced, and then generalization to novel stimuli is tested.

Although early research on oddity with humans seemed to indicate that responding in accordance with oddity relations was very difficult to demonstrate in individuals with developmental ages below four years (e.g., Ellis & Sloan, 1959; House 1964; Saravo & Gollin, 1969), later studies have had success with a variety of procedures for training oddity with individuals at younger developmental ages, including individuals with developmental disabilities. Several factors may influence performance at early developmental levels of functioning. As noted, a number of researchers have suggested that people with developmental delay may have a lower sensitivity to (i.e., ability to discriminate) particular inter-stimulus relations in general than typically developing individuals (Soraci, Carlin & Bray, 1992; Carlin, Soraci Jr, and Strawbridge, 2003). For example, it may be more difficult for them to perform correctly in an oddity task involving a small array of stimuli in which the “odd” stimulus is similar in some dimension or feature to the other stimuli. In addition, performance on some oddity tasks requires both attending to the oddity relation itself (i.e., responding to the difference between stimuli), as well as attending to a specific dimension (e.g., form, color, or size) along which the stimuli differ. Children may have a predisposition to attend to one dimension more than another, with younger children demonstrating a dimensional preference for color and older children for form (e.g., Suchman & Trabasso, 1966), and this may then affect their performance on oddity tasks. Thus, increasing the salience of the relevant relations between stimuli (e.g., making the “different” stimulus quite distinct—such as one elephant among many mice) and/or the relevant dimensions of stimuli could be expected to facilitate oddity (and identity) matching, and several methods of doing so have been explored.

One general method of increasing the salience of inter-stimulus relations involves organizational manipulations of the array, including (a) increasing the number of “non-odd” stimuli in an array and (b) increasing stimulus contiguity. For example, Zentall, Hogan, Edwards, and Hearst (1980) found that increasing the number of non-odd stimuli to eight (rather than two) not only facilitated acquisition of oddity learning in pigeons, but also facilitated transfer of their performance to an array of only two non-odd and one odd stimuli. Soraci et al. (1987) found similar results with such a procedure for young children identified as at risk for developmental disabilities. Increasing stimulus contiguity (i.e., eliminating space between stimuli) has also been found to facilitate oddity learning with either small (e.g., three non-odd stimuli) or large (e.g., eight non-odd stimuli) arrays (Bryant & Soraci, 1991, as cited in Soraci et al., 1992, p 36).

Soraci et al. (1992) also review two methods of increasing the salience of the relevant dimensions (e.g., color vs form) of the matching stimuli. One way is to assess individual dimensional preferences such as by using stimuli which vary in both color and form and determining which dimension is attended to in a matching task (e.g., given a red airplane as a sample, and a red car or a blue airplane as the comparisons, which comparison does the child choose?). Oddity tasks may then be used which focus only on the more salient dimension. A second method is to specifically train attending to the relevant dimension, such as by first reinforcing identity matching on the basis of the relevant dimension (e.g., given the previous example, one could reinforce matching on the basis of color—matching the red car and red airplane—rather than form) before testing oddity on that dimension.

Finally, Soraci, Deckner, Baumeister and Bryant (1991) found that pairing a tone with visual stimuli during oddity tests (i.e., the non-odd stimuli were paired with one tone, while the odd stimulus was paired with another) facilitated oddity performance. In this study, preschool children who had previously failed oddity tasks with visual stimuli alone were able to pass using the paired stimuli, and that skill transferred to oddity tasks using novel visual stimuli alone.

Through methods to increase salience of the relevant variables such as those described above, children with developmental delay have been taught to pass tests of

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identity and oddity, and a similar strategy using oddity has even been used to train identity with children who had failed tests of identity matching. Mackay et al. (2002) trained children in an identity MTS task that first used a comparison array of eight incorrect comparisons (all identical to each other but different from the sample) and one correct comparison (identical to the sample, but different from the other comparisons) to guide attention to the correct sample. Thus, initially, the children could make a correct selection on the basis of oddity alone, within the comparison array. Gradually over time, the size of the comparison array was reduced, until the array consisted of only one correct and one incorrect comparison stimulus. Using this procedure, both children with and without developmental delay were taught to pass identity matching tests that had previously been failed; in addition, for some children, only very brief training was needed, suggesting the potential efficiency of this method.

Directions for future research. While there are several well-established procedures for facilitating oddity responding, as described above, we can also look to research on identity matching for some direction on procedures that may be applicable to oddity and which might be fruitfully explored in future research. In particular, there is a well-established long-term translational behavior analytic research program at the UMMS Shriver Center (see McIlvane, 2009) studying stimulus control and identity matching procedures with individuals with developmental disabilities. Serna, Dube and McIlvane (1997) identify critical variables to attend to when teaching individuals to respond to tasks requiring identity matching. These include whether the MTS task is non-conditional (i.e., the S+ and S- stimuli do not change across trials) or conditional (i.e., the S+ stimulus on one trial could change to be an S- stimulus on another trial). Their recommended teaching sequence is to proceed from simple discrimination to non-conditional to conditional identity matching. In addition to the work reported by the Shriver program, preverbal toddlers (16-21 months) have been successfully trained in identity matching using this sequence of procedures (de Alcântara Gil, de Oliveira, & McIlvane, 2011). While this sequence has not yet been studied with oddity matching, it might be a reasonable procedural sequence to examine.

In addition, there is insufficient evidence to determine whether oddity and identity training should proceed simultaneously or in a particular sequence, and further research on the best sequence of training is warranted. In general, ABA programs have typically focused almost exclusively on identity, ignoring oddity. As noted previously, from a logical perspective it might seem difficult to separate the two—being able to identify an item that is the same necessarily also entails avoiding the selection of an item that is different, and vice versa. However, research such as that conducted by Mackay et al. (2002) would suggest that identity and oddity are indeed separable at the level of behavioral repertoires and thus that an individual might be able to respond in accordance with one before they learn to respond in accordance with the other. As such, future research might usefully examine whether training these repertoires in a sequence or training both simultaneously is the most efficient as regards establishing both.

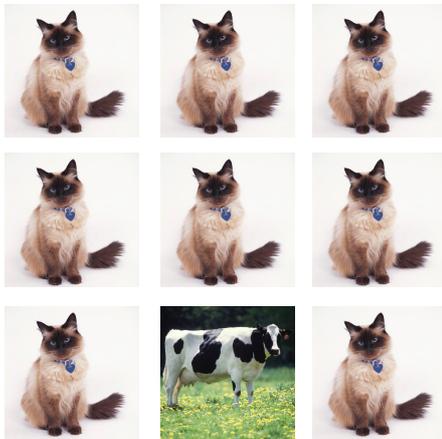
Implications for clinical practice. It would appear that, with appropriate procedures, many organisms—and certainly humans with developmental disabilities—can be taught the very basic relational skill of oddity responding. However, there appears to be no early intensive behavioral intervention (EIBI) curricula for children with autism that attempt to teach responding on the basis of oddity. Given that this may be the earliest point at which a *new*, non-sameness relational response might be expected, and given the importance of difference relations to generalized cognitive skills as well as the importance of flexibility of responding in accordance with a variety of relations (e.g., see O'Toole & Barnes-Holmes, 2009), this should be considered an important gap in programming for very early learners, and one for which there are already established procedures to utilize as discussed above.

Oddity responding might be introduced fairly early in a training program. Oddity training should progress from large arrays of closely spaced stimuli to a small array (ultimately two non-odd and one odd stimuli), as described by Soraci et al. (1992) (see Figure 7.1 for examples). When training oddity, just as with training identity, it is important to work with a variety of stimulus sets: once oddity selections are accurately made with one set of stimuli (e.g., eight cats and one cow), a new set

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should be used for training (e.g., eight dogs and one horse), until oddity is accurately demonstrated with novel sets and with the odd stimulus in a variety of positions, at which point the array may be reduced. As regards oddity, the response is not yet under the differential control of a contextual cue such as “different”, so the teacher must establish “how” to respond to the task first, such as by demonstrating the task requirements with the first stimulus set during the session and then presenting the task with a novel set.

Initial Array:



Final Array:

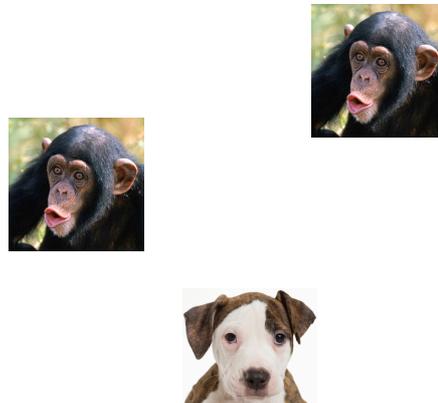


Figure 7.1. Types of arrays used for oddity tasks, progressing from large arrays of stimuli in close proximity to small arrays in less proximity, using MET with different stimulus sets on each trial. In such tasks, the response requirement is to select the nonidentical stimulus.

If necessary, auditory stimuli might also usefully be paired with visual stimuli to help establish oddity responding (Soraci et al., 1991), although this may be less practical in a table-top teaching format than with an automated program. Nonetheless, using toys/items that themselves make different noises (e.g., several front-desk bells and one bicycle horn) might be a reasonable—and probably enjoyable—way to accomplish this.

Finally, for students who have some strong identity matching skills but are struggling with oddity, it may be beneficial to assess for a predisposition to attend to

one dimension over another (e.g., color vs form) in matching tasks, and then use that dimension as the focus in oddity tasks (Soraci, et al., 1992). For example, if a student readily matches a red car to a red airplane rather than a blue car (given only the direction to “match”), then oddity training might involve presenting several stimuli of the same color alongside one of a different color (e.g., eight blue cars and one red car); for students who matched the cars, oddity training might present several stimuli of the same form, along with one of another form (e.g., eight planes and one boat).

Non-arbitrary relational matching

Relational matching involves selecting a pair of items from amongst a number of comparison pairs that exemplifies the same type of relation as a sample pair. For example, such tasks might require matching a pair showing two squares (same) to a pair showing two triangles (same) rather than a pair that contains a circle and a star (different), or matching a pair showing a cow and a pig (different) to a pair showing a horse and a duck (different) rather than a pair showing two cats (same). This type of responding might be seen as a simple or precursor form of analogy, which in turn is seen both as an important skill in itself as well as a measure of intellectual performance (e.g., Sternberg 1977; Ortony 1979). The definition of analogical responding itself might perhaps be restricted to the relation of arbitrary or abstract relations; however, if defined more broadly as the relating of relations, it might include the relation of non-arbitrary or physical relations also. Even if one confines the definition of analogy to the relation between abstract relations, however, or at least sees the latter as an important or key type of analogy, training the matching of non-arbitrary same/different relations might at least provide an important early foundation for this repertoire.

There are several decades of research into this type of simple analogy with primates, as well as more recent research with corvids. Thompson et al. (1997) demonstrated that chimpanzees with a history of training to select a specific token (triangle) when shown a “same” pair, and a different token (diagonal) when shown a “different” pair (i.e., relational tacting, as discussed previously) were subsequently able to demonstrate relational matching. Furthermore, they performed at levels

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similar to chimpanzees trained over many years in quasi-linguistic behavior (i.e., trained to use symbol-like stimuli or sign-like responses, see Premack 1978, 1983). Meantime, a chimpanzee without similar training was not able to demonstrate relational matching. Thompson and Oden (1996, 2000), in reviewing the experimental research on such relational matching, concluded that organisms must be trained in what we refer to here as a relational tact in order to perform a relational match. However, more recent research indicates that some primates and pigeons can be trained to perform relational matching without such a history, given sufficient training exemplars and sufficiently individualized stimulus presentations (e.g., small or large array size) (Vonk 2003; Flemming, Beran, Thompson, Kleider, & Washburn, 2008; Cook et al., 2003; Truppa, Piano Mortari, Garofoli, Privitera, & Visalberghi, 2011). Recent research has even shown that corvids may be able to show relational matching having only been trained in identity matching (Smirnova, Zorina, Obozova & Wasserman, 2015).

With respect to non-arbitrary relational matching in humans, there is no research that parallels the type of relational matching of “same” and “different” relations seen in the non-human literature. Most research with humans has focused on analogy based on arbitrary relations. However, some cognitive developmental researchers focused on testing analogical problem solving in young children have used tasks that might be seen as requiring the matching of non-arbitrary relations (e.g., Markman & Gentner, 1993; Ratterman & Gentner, 1998; Richland, Morrison & Holyoak, 2006). For example, in “scene analogy” problems, a scene is presented showing a particular relation or action, such as a small boy next to a large man, or a dog chasing a cat. A second scene is presented showing the same relation but with different stimuli, such as a small bear next to a large bear, or a boy chasing a girl. The experimenter then points to one of the stimuli in the first scene, and the task is for the participant to point to the corresponding stimulus in the second; for example, if the experimenter pointed to the small boy, the participant would point to the small bear. In these problems, the complexity of the relations involved are increased in subsequent presentations, and distracters with features that are similar are introduced (for example, there might be a picture of a small boy next to a baby, rather than a

small bear next to a large bear). The purpose of such experiments has been to identify the differences between younger and older children with respect to inhibiting responding to distracters and responding to more complex relations, as a means of testing various cognitive theories of the development of analogy. One finding from such research of direct interest in the current context is that many children as young as 3-4 years were able to respond to problems with a single relation presented and no distracters (Richland et al., 2006).

Directions for future research. To date, there appears to be little or no research on teaching non-arbitrary relational matching with humans. This seems to be a significant gap, as it would appear to be a potentially important element of a generalized repertoire of relational responding in a frame of difference, as well as a potentially important precursor to analogy. A number of different issues might be examined. One question concerns the stage in the typical developmental sequence at which non-arbitrary relational matching begins to be seen in children, including both typically developing and developmentally delayed. For example, does relational matching typically precede or follow relational tacting and/or listener behavior, and might this order be changed based on targeted training? A second concerns the best methods with which to establish and strengthen this repertoire. For instance, how might training of related repertoires such as relational tacting and/or listener training compare with or interact with multiple exemplar training (MET) of the repertoire itself as means of establishing or strengthening this capacity? Might training involving the matching of a range of different varieties of relations be better than training involving a more limited set? How effective might use of stimulus arrays similar to those used in establishing oddity selection (e.g., a comparison array of many “same” pairs with one pair that shows “different”, and a “different” pair as sample, or vice versa) be? A further issue concerns the effect of training non-arbitrary relational matching on the emergence of arbitrary relational matching (the form of behavior to which, as discussed, the label “analogical reasoning” is most frequently applied) and/or other arbitrary relational (i.e., relational framing) abilities as well as on intellectual performance more generally.

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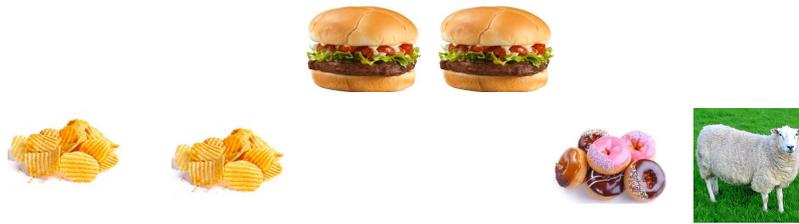
Implications for clinical practice. Once both oddity and identity responding are established as discussed previously, non-arbitrary relational matching might next be introduced. As noted above, there is insufficient evidence, particularly with humans, to identify the appropriate sequence of teaching non-arbitrary relational matching, tacting, or listener discriminations (as discussed next). Research will hopefully provide insight on this question. In the meantime, beginning with relational matching using procedures similar to those already shown to be successful with non-human animals might be the most reasonable approach. In this task, additional contextual cues are not necessary for correct responding—the student need only attend to the relation itself demonstrated by the sample pair, rather than attending to contextual cues of “same” or “different”. The MTS context itself should be quite familiar to most students by this point, and is likely to evoke responding on the basis of the similarity of the sample to comparison—in this case, however, the similarity of the *relation* in the sample to the relation shown in the comparison is what is being matched. As an additional suggestion, it may be more useful to start with tasks that require only matching on the basis of the “same” relation, and that involve highly distinct pairs (i.e., match AA to BB vs CD, with multiple sets of stimuli); next, more similar pairs (i.e., match AA to BB vs BC) might be introduced; and then, tasks involving both “same” and “different” relations might be employed (see Figure 7.2 for examples).

Non-arbitrary relational listener discriminations and relational tacts

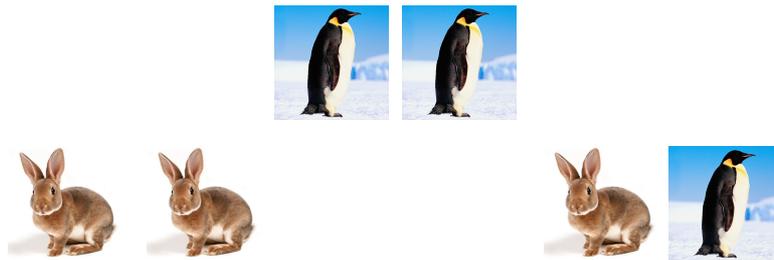
While still primarily forms of non-arbitrary relational responding, both non-arbitrary relational listener discriminations and relational tacts involve responding in accordance with an arbitrary designation of the relational response in question. Non-arbitrary relational listener discriminations require responding under the control of relevant contextual cues—stimuli discriminative for either “same” or “different” matching responses (e.g., the textual stimuli “same” or “different”). Non-arbitrary relational tacts require identifying the relation between items, either through a topographical response (e.g., a vocal or sign based response of “same” or “different”

or their functional equivalent) or by selection of the appropriate relational name (e.g., text or symbols indicating “same” vs “different”).

I: Relational matching “same”—distinct stimuli



II: Relational matching “same”—more difficult discrimination



III: Relational matching “different”



Figure 7.2. Examples of nonarbitrary relational matching tasks.

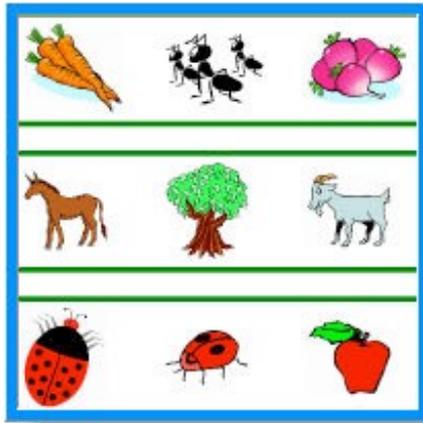
Relational tacts and listener responses can range from responding to identical vs non-identical items as the “same” or “different” to much more complex

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performances such as responding on the basis of *how* two items might be the same or different from one another (the foundation of most compare/contrast requirements in academic tasks). Examples abound not only in preschool worksheets, but also in other arenas, such as training musical listening skills by requiring learners to listen to two tones and identify if they are the same or different (e.g., EarTrainingandImprov.com, 2012). The classic “Sesame Street” game of “One of these things is not like the others” is a good example of these kinds of tasks at a slightly more advanced level—that is, having to identify an item as being different from the others on the basis of features other than simple identity/oddity (see Figure 7.3 for examples). Examples at the early elementary level include Common Core standards that require students to “analyze and compare two and three-dimensional shapes, in different sizes and orientations, using informal language to describe their similarities, difference, parts (e.g., number of sides and vertices/”corners”) and other attributes (e.g., having sides of equal length)” (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010, <http://www.corestandards.org/Math/Content/G/>), and to “identify basic similarities in and differences between two texts on the same topic (e.g., in illustrations, descriptions, or procedures)” (<http://www.corestandards.org/ELA-Literacy/RI/1/9/>).

Non-arbitrary relational listener discriminations have been studied and demonstrated with a number of primate species, both in a MTS format in which either an identical or non-identical comparison is selected, depending on a cue (e.g., Robinson 1955; Thomas & Kerr, 1976; Burdyn & Thomas, 1984), or in which an identical or non-identical comparison *pair* is selected, depending on a cue (i.e., non-arbitrary “analogical” responding; e.g., Flemming, Beran, & Washburn, 2007). In the experimental literature, such cues are often differently colored or differently patterned stimuli; depending on the cue displayed, selecting one or the other of the comparisons is reinforced. Such tasks might require responding only on the basis of a single dimension (e.g., shape) throughout, or might require a more complex level of responding such as selecting among multi-dimensional stimuli for an item that is the “same” or “different” with respect to a specific dimension; for example, “same color” or “different size” (e.g., Vonk, 2003) (see Figure 7.4 for examples).

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Source: www.prek-8.com

Name _____ All About Us Self-Awareness
Same

This is _____ We have the same



This is _____ We have different

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Source: www.theeducationcenter.com

Same or Different? Catching Bugs

Listen to the sounds the bugs make. If the two notes sound the same, draw a line to the 'SAME' jar. If they sound different, draw a line to the 'DIFFERENT' jar.

1. 2. 3. 4. 5.

SAME

DIFFERENT

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Source: www.eartrainingandimprov.com

Animals: Compare and Contrast

Dragonfly

Bird

Compare dragonflies and birds. (Find things that are similar)

They both have wings.

Contrast dragonflies and birds. (Find things that are different)

Birds have two legs, but dragonflies have six legs.

Source: www.bogglesworldesl.com

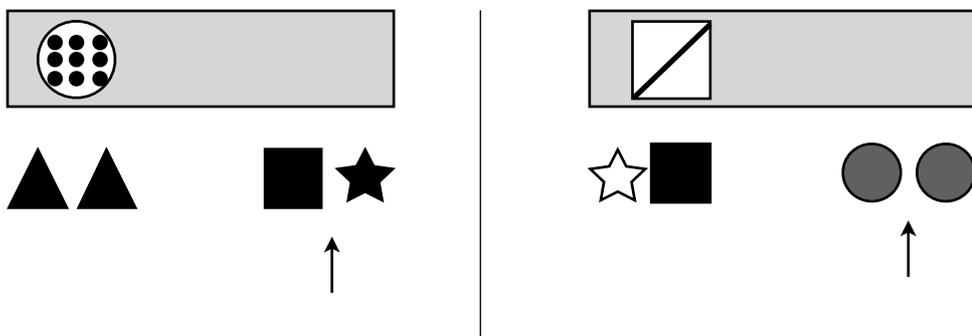
Figure 7.3. Nonarbitrary relational responding—educational activities.

There is also substantive data from research with nonhumans that has investigated non-arbitrary same/different relational tacting. Using discrimination training and MET, a variety of species have been taught to identify pairs of items as being the same (e.g., two squares) or different (e.g., a square and a triangle) (see, e.g., Pepperberg 1987, 1988; Thompson, Oden, & Boysen, 1997; Fujita 1983; Bhatt & Wright, 1992; Flemming et al., 2007; Mercado et al., 2000; Scholtyssek, Kelber, Hanke, & Dehnhardt, 2013; Blaisdell & Cook, 2005; Cook, Kelly, & Katz, 2003; Katz & Wright, 2006; Edwards, Jagielo, Zentall, & Hogan, 1982). While required

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response topographies have varied, in all instances, the subjects were successfully trained using discrimination training procedures to make one response in the presence of two same novel items, and another response in the presence of two different novel items. For example, Katz and Wright (2006) taught pigeons to peck an upper picture as the sample, which brought up two comparisons: another picture and a white rectangle. The pigeons were taught to peck the comparison picture if it was the same as the sample, and to peck the white rectangle if the two pictures were different.

First order “same/different” pair selection using symbolic cue



Second order “same/different” selection

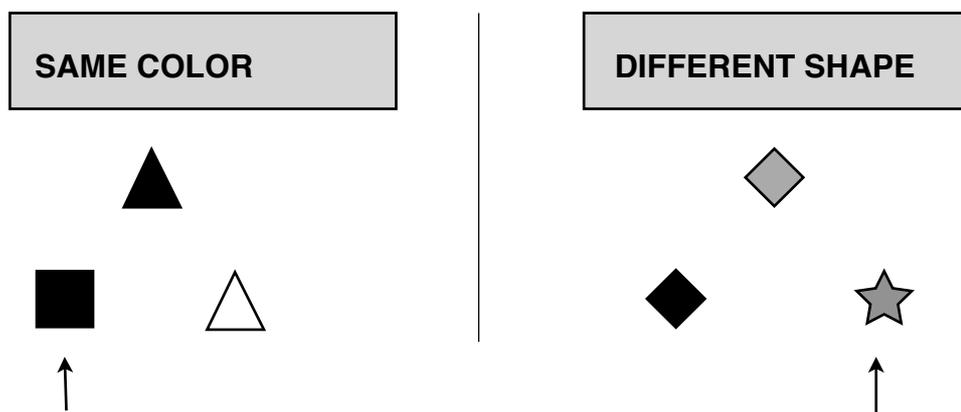


Figure 7.4. Contextually-controlled “same/different” non-arbitrary listener discriminations.

Pepperberg (1987, 1988) trained an African Grey parrot (Alex) in several more complex tasks requiring second order same/different relational tacting. As Alex had been previously trained to identify abstract categories of color, shape, and material, these categories were used for training him to tact what *properties* of two items were either the same or different, or if no properties were same or different. After MET with various pairs of items with the questions “What’s same?” or “What’s different?”, Alex was able to correctly respond to pairs of novel objects by vocally tacting same/different relations with respect to color, shape, material, or state that “none” of the properties were the same or different.

Relevant to relational tacting of same/different, Serna et al. (1997) describe research on developing non-vocal procedures for humans that are very similar to some of the procedures used with non-human subjects as described above. A “blank comparison” procedure allows non-vocal individuals to identify (i.e., tact) whether or not a comparison is the same as the sample. With these procedures, an individual can be taught to press a matching comparison if it is the same as (or similar to) the sample, and to press a blank comparison if not.

As described in Chapter 2, Howard and Rice (1988) taught preschool children (age 4-5) responses that might be considered under the category of relational tacts of degrees of difference/similarity (which they termed autoclitic tacts, as we have discussed above), in the only published study examining this skill in an applied setting with children. The children were taught to tact particular items, and then were trained to describe the “weakness” of distorted examples of those items (e.g., describing a distorted square figure as, “like a square”). This structured training resulted in all children being able to use the autoclitic phrases with novel samples, and with one of the children coming up with novel autoclitics (e.g., “not a very good H”).

Directions for future research. No studies examining teaching relational same/different listener discriminations with humans were found in conducting this review, despite this task being present in several curricula for children with autism. In addition, there appears to be very little research on relational tacting other than the limited work referred to above. Obvious directions for future research, therefore,

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might involve assessment and where necessary, training of these skills in both typically developing and developmentally delayed children. Such research might form part of a larger project investigating the emergence and interaction of the elements of a repertoire of non-arbitrary same and different relational responding in different methodological contexts (relational matching, listener and tacting tasks) and at differing levels of complexity (e.g., unidimensional versus multidimensional). This work might involve assessing and training listener and tacting repertoires using protocols similar to those previously employed in nonhuman work, and perhaps comparing them in terms of their efficacy. The transfer of non-arbitrary relational skills from listener to tacting and vice versa might be investigated as well as transfer between these skills and relational matching. Such work might form the basis for a detailed curriculum in which skills are appropriately and efficiently sequenced from simple to complex and learning at earlier stages is maximally transferrable and supportive of learning at later stages.

In the next section, suggestions are made for clinical practice. These are currently unsupported in terms of empirical research with humans, but represent educated guesses as to what might be useful as regards teaching non-arbitrary relational listener and tacting skills in the applied domain. These suggestions might also be drawn upon as a source of ideas for procedures for use in empirical research on assessment and training of these skills.

Implications for clinical practice. As regards training non-arbitrary relational listener and tacting skills, procedures as used in the non-human literature as well as procedures in common use in language intervention programs can provide some guidance. That is, it can be seen as a relatively straightforward matter of discrete trial training to teach the selection of an item that is “different” or the “same” as a sample, much as one would teach the selection of an item based on its name (“find the dog”). Similarly, procedures that are already in widespread use for teaching tacting might be used to teach tacting of the relation between stimuli, by using MET with sets of “same” or “different” pairs of stimuli. However, this task may be more difficult for many children than seems at first glance, and thus previously trained responses might beneficially be utilized to provide more errorless

learning opportunities. It may be helpful to expose students to cues for “same” and “different” errorlessly during relational matching, once relational matching is established. For example, a transfer procedure for identifying a pair that shows “same” vs a pair that shows “different” could reasonably shift control from a sample pair plus contextual cue to the contextual cue alone. Tacting the pairs as “same” or “different” might then more easily follow. Strategies as discussed previously with respect to oddity training could also be beneficial in terms of altering the array to make selection of the correct pair more likely (e.g., if the requirement is to find the pair that shows “different”, there might be several pairs of identical items, and one pair of non-identical items, or vice versa if the requirement is to find the pair that shows “same”). Selecting a single comparison that is “same” or “different” from a sample could follow from there.

After a basic foundation of non-arbitrary relational matching, listener discriminations and tacting has been established, this repertoire should most likely be strengthened (as well as ensuring relational responding in accordance with frames of coordination is well-established) before moving on to arbitrary relational responding in accordance with difference (as will be discussed below). Same/different relations within different modalities (e.g., auditory tones/volume, tactile features, smells) could be worked on, and second-order difference relations (different vs same color, shape, size, material, number of legs, etc.) might be introduced at this point to establish a broader and more flexible range of responding in accordance with various combinations of criteria.

Yes/no responding with non-arbitrary stimuli in relations of same and different might also be introduced as important skills in and of themselves as well as a foundation for later arbitrary yes/no responding. That is, students should be able to identify whether a pair of items is or is not same or different with non-arbitrary stimuli (e.g., “are these the same?”/“are these different?” with physically identical vs different items), or find an item that is “not same” or “not different.” Students who have difficulty with this task might benefit from the procedures described by Serna et al. (1997), and similar procedures used with nonhumans—that is, procedures in

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which the learner is taught to select a matching comparison, or to select a blank card (or make some other response) if the comparison is different from the sample.

Research has found that training non-arbitrary relational responding can provide an important foundation for emergence of robust arbitrary relational responding (e.g., Barnes-Holmes, Barnes-Holmes & Smeets, 2004; Berens & Hayes, 2007). The same thing likely applies with frames of distinction as with other frames. In this case, once students are skilled in non-arbitrary relational responding based on procedures such as described above, they might be assessed for same and different arbitrary relational responding using, for example, picture-name combinations (e.g., “Is this a cat?”/“Find the one that is not a cat”), in which the relation is based on social convention (the word is the “name” of the picture) rather than physical attributes, as we will discuss further below. Parenthetically, it should be noted that many programs for children with autism teach such yes/no tacting and listener discriminations without necessarily testing for responding with yes/no at the earlier, non-arbitrary level of physical identity/difference. We would recommend a thorough determination of participants’ skills at the non-arbitrary relational level before teaching or testing arbitrary relational responding skills.

In summary, non-arbitrary relational responding in accordance with difference has been demonstrated with a variety of species across several types of relational responses, and there are well-documented experimental procedures in the literature. However, there appears to be a significant gap with respect to applying the procedures used in research with nonhumans to do research or practical work with children who have skill deficits in this area, and there is no clear evidence for a particular sequence or hierarchy of teaching relational tacting, listener discriminations or matching. Relevant research into assessment, training and interaction of these skills is needed therefore including, for example, exploring which ones might most efficiently facilitate the others, and thus be targeted first, as well as what effect this might have on arbitrary relational responding within frames of difference and beyond.

Arbitrary Relational Responding

As discussed earlier, in arbitrary relational responding (also referred to as relational framing), stimuli are related (e.g., as the same as or different from each other) based on contextual control rather than their physical properties. The capacity for arbitrary relational responding allows the derivation of new relations independent of physical properties of the related stimuli and thus facilitates rapid learning and generativity to an extent that neither non-arbitrary relational responding nor direct operant training can do (e.g., Stewart & Roche, 2013). Learning to respond in accordance with arbitrary same and difference relations can substantially add to the individual's capacity to learn. Of particular importance, such skills likely provide the foundation for further key repertoires including abstract categorization, which involves classifying objects and events together as well as distinguishing them across multiple different verbal dimensions (see, for example, Hayes, Gifford, Townsend & Barnes-Holmes, 2001; Gil, Luciano, Ruiz & Valdivia, 2012; Slattery & Stewart, 2014). Furthermore, recent empirical evidence of substantial improvements in reading comprehension of typically developing children based on MET of arbitrary same and different relations (K.B. Newsome, Berens, Ghezzi, Aninao, & W.B. Newsome, 2014) would appear to cohere with this conclusion, as will be discussed further below and in Chapter 8.

As with non-arbitrary relational responding, arbitrary relational responding in accordance with difference/distinction might involve listener responses, relational tacting, or relational matching. The common factor in all cases is that the relational responding would be primarily contextually controlled and involve arbitrarily designated relations (relational frames) of distinction. In the sections to follow, behavior analytic research relevant to this type of responding will be considered, starting by examining some possible precursors to arbitrary difference relational responding. Research on arbitrary difference relational responding itself, including work involving both arbitrary relational tacts and listener discriminations will then be reviewed. Finally, relational matching in the realm of arbitrary sameness and difference will be considered by examining analogical relational responding.

Precursors to derived relations of distinction

Exclusion. Conditional discriminations based on difference, as might be involved in pretraining given prior to probing for derivation in accordance with the relational frame of distinction, involve simply selecting an item on the basis of its arbitrarily designated difference with another stimulus. Empirical work specifically looking at establishing such conditional discriminations in accordance with arbitrary difference has been studied within the context of RFT studies examining frames of distinction as we will discuss below (e.g., Roche & Barnes, 1996; O'Hora, Barnes-Holmes, Roche, & Smeets, 2004). However, before considering relational framing in accordance with distinction, another phenomenon in the context of conditional discrimination and stimulus control seems worthy of mention: exclusion.

The phenomenon of exclusion is seen when, given a history of a well-established MTS performance with a set of arbitrarily related stimuli, a novel unfamiliar comparison stimulus is selected in the presence of a novel unfamiliar sample stimulus without additional training. As such, exclusion procedures can lead to matching of arbitrary stimuli in the absence of any explicit reinforcement (*emergent matching*; see Wilkinson, Dube, & McIlvane, 1998, for a review of this research). From the point of view of this review, exclusion seems relevant to arbitrary difference relations because it appears to involve responding influenced by perceived incongruity. In fact, on the basis that exclusion can occur, it has been theorized that the type of stimulus control responsible for establishing MTS performances more generally may involve not simply *selecting* (i.e., responding towards) the correct comparison (S+) but also *rejecting* (i.e., responding away from) the incorrect comparison(s) (S-) (e.g. Dixon & Dixon, 1978; Stromer & Osborne, 1982).

Research examining S+ vs S- control has involved substituting either the S+ or the S- in a MTS task with an ambiguous stimulus (i.e., one with no history establishing it as either S+ or S). If an ambiguous stimulus replaces the S+ and is selected instead of the S-, then that has been taken to indicate control by the rejection of the S- while if the latter is replaced by an ambiguous stimulus, and the S+

continues to be reliably selected, that has been taken to indicate control by the S+. Stromer and Osborne (1982) found that, for adolescents with developmental disabilities in their study, control over baseline conditional discriminations as well as derived relations appeared to involve *both* S+ and S- control. They noted the use of explicit verbal instructions and differential feedback as possible factors in the development of such stimulus control.

Theorists have argued that understanding what type of stimulus control has been established in any particular study is important for understanding and influencing the outcomes of derived relational training and testing. For example, Carrigan and Sidman (1982) analyze the potential outcomes of stimulus equivalence testing following different training circumstances when control is exclusively by rejection of the S-, and make several recommendations on this basis. These include testing for reflexivity (i.e., identity matching) following the establishment of baseline relations in order to facilitate control by the S+, embedding test trials in baseline relations training, and using a minimum of three comparisons. In regard to the latter, Boelens (2002) has argued more recently that the technical drawbacks of using a two comparison test can be relatively easily overcome by procedures such as including multiple derivation tests and stringent criteria for all derivation tests, as was discussed in Chapter 4.

In relation to the overlap between exclusion and derived relations, one other phenomenon which has appeared in the literature is testing for the combination of these events. Lipkens, Hayes and Hayes (1993) showed two versions of exclusion when tracking the emergence in a young infant of derived relational responding. One version, which was first recorded at 16 months of age, was the straightforward version discussed above. The other, which only appeared at 23 months of age, was a version in which responding was based on a combination of both exclusion and derived relational responding. More specifically, in this case the child had to not only choose a novel stimulus with a novel comparison, but had to do so in the context of a conditional discrimination task in which the other sample-comparison relation had not been directly trained but was a derived symmetrical relation. This latter

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performance, which might be referred to as *derived* exclusion, might seem particularly relevant as a precursor to arbitrary difference relational responding.

Yes/No conditional discriminations. In much of the research into arbitrary difference relations, certain relations are trained, in order to subsequently probe for the derivation of others. For example, the first step in investigating frames of distinction is to train the relevant arbitrary conditional discriminations—e.g., establishing that A is the same as B, and B is different from C. After the latter performances have been trained then testing for further untrained or derived relations (e.g., A different from C and vice versa) can be done. Apart from work in which relations are trained in order to allow researchers to probe for further derived relations, however, there is also a domain of theory and research that has focused on trained relational performances themselves. This is important to consider both for what it might reveal about possible precursors to derived sameness and difference relational responding as well as in its provision of methods for tapping into such performances.

At the non-arbitrary level, “go/no-go,” and “yes/no,” (D'Amato & Worsham, 1974) procedures train two different responses depending on whether a successively presented pair of stimuli have been established as “going together” or not—this can be seen as analogous to identifying the pair of items as being the same or different from each other. What would generally be termed descriptive autoclitic tacts of assertion and negation in the Skinnerian verbal behavior literature involve similar responses at the arbitrary level. In this case, negation would imply “not-same” or “different”. For example, when answering the question “Is this a cat?” when presented with a dog, saying “no” would require the student to identify the item presented as being “not the same as” or “different from”, the word “cat.” As an intraverbal response, answering the question “Does a cat say woof?” requires the student to identify that “cat” and “woof” don’t belong together or that they relate to different things. In these cases, the relation of the stimuli “cat”, “dog” or “woof” to each other are arbitrary relations. Similarly, selecting an item on the basis of its (arbitrarily designated) difference from a sample could also include identifying an item that is “not” the same as a sample—such as in common teaching procedures for

“negation” (e.g., Leaf & McEachin, 1999), in which a student is asked, for example, to find the stimulus that is “not a cat” from an array that includes a cat and a dog. Hence in this section we briefly review research related to tact and intraverbal responding with “yes/no” as discussed in the verbal behavior literature as well as relational listener discriminations involving selections based on assertion/negation.

There is little applied research on teaching individuals to demonstrate such arbitrary conditional discriminations on the basis of sameness/difference between stimuli when they are not already able to do so. Two studies working from a Skinnerian verbal behavior perspective have attempted to teach participants to use “yes” or “no” as tact or intraverbal responses, using discrete trial teaching procedures. In the first of these, Neef, Walters and Egel (1984) examined teaching procedures for “yes/no” for both mand and tact responses. Children with developmental delays were taught “yes/no” mands through embedded instructional procedures (mand training). However, this skill did not generalize to “yes/no” tacts; the latter were only acquired when the teaching procedures included specifically programming alternating trials of tacts and mands. Shillingsburg, Kelley, Roane, Kisamore and Brown (2009) examined procedures for teaching children with autism “yes/no” across mands, tacts, and intraverbals, with a focus on determining the functional independence of these responses. They found that responses of “yes/no” could be taught to children as mands (e.g., “Do you want a chip?”), tacts (e.g., “Is this a cup?”), and intraverbals (e.g., “Does a dog say moo?”) and generalized within but not across operants. We would note that additional information about participants’ other relational responding skills both at non-arbitrary and arbitrary levels in frames of coordination and distinction might be helpful in determining factors that could potentially facilitate such generalization.

Directions for future research. Future work investigating difference relational responding could examine the importance of exclusion (in both basic and derived versions) as well as yes/no responding (in each of several Skinnerian verbal operant forms) as precursors to non-arbitrary and arbitrary difference relations, considering whether either of these abilities (including their variants) is correlated with or might support the learning of non-arbitrary and arbitrary difference relations.

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A consideration of the issue of S+ vs S- control in the context of training and testing arbitrary difference relations would also be worth pursuing. In addition, there is much to be done with respect to identifying appropriate and efficient methods for teaching exclusion and yes/no responding and their variations for individuals who are not yet able to demonstrate these skills. Several potential training avenues are described below which would also benefit from study with respect to efficiency, generalization, and which skills might facilitate the acquisition of others. Future research might also examine the use of “yes/no” procedures as means of assessing and training both non-arbitrary and arbitrary relational responding.

Implications for clinical practice. As noted, there is little research to guide the interested clinician. Although the exact importance of exclusion in both its basic and derived forms to difference responding remains to be investigated, as described above, exclusion and derived difference relations seem at least conceptually related. Thus it would seem reasonable that prior to embarking on a program of training arbitrary difference relations, one might first test both basic and derived exclusion. For basic exclusion, this could be done relatively simply by presenting a novel stimulus along with previously trained stimuli, and asking the student to select the novel stimulus. For example, the child might first be taught using MTS to choose particular pictures in the presence of particular auditory stimuli, thus producing two unidirectional relations [A1-B1] and [A2-B2]. They might then be tested for exclusion by presenting one of the trained pictures alongside a novel picture [B3] and asking for a novel name [A3]. To test derived exclusion, the child might first be trained to say particular words in the presence of particular pictures. The test could then be similar to the test for basic exclusion; the difference would be that this time the “known” stimulus relation would be known through derived symmetry rather than direct training. On a practical note, unusual hardware store items or images of unusual dog breeds or other animals or musical instruments prove useful for ensuring that the stimulus presented is truly novel. For example, one might teach a student to tact a particular picture as a “gao hu”, and another picture as “ocarina”, and then present the picture of the ocarina with another picture, and ask the student to “find

the zither”. With individuals who do not readily demonstrate basic or derived exclusion, MET with novel sets of stimuli may be an avenue to explore.

It might be anticipated that once a solid foundation of non-arbitrary responding in accordance with difference is established, training in arbitrary conditional discriminations may proceed. As noted earlier, it might be best to start by transitioning from existing skills, such as might be done by beginning with yes/no tacting and listener discriminations of familiar items—that is, identifying the sameness/difference between an item and a name (e.g., “Is this a cat?”). Variations that could help the transition might include using a picture and text (e.g., picture of a cat and the word CAT or the word DOG), and asking the student to tact whether they are the same or different (either with “yes”/“no”, or with “same”/“different”); given the likelihood of the student tacting the picture and vocally reading the text, this represents less arbitrariness in the to-be-evaluated sameness or difference relation than in the case of totally new relations.

Arbitrary relational listener discriminations and relational tacts

Having covered its precursors, derived arbitrary distinction relational responding itself will now be considered. As explained previously, arbitrary relational responding is based not on non-arbitrary properties of the stimuli related but on contextual control. As a result of the latter, training part of the relational pattern in a given set of stimuli reliably allows additional relations to be derived no matter what the actual properties of the stimuli in question. This section will first consider research that has examined derived arbitrary distinction relations by examining listener discriminations and relational tacts. In the next section relational matching or analogy will be considered.

Generative properties of frames of distinction. Most of the existing work on derived relations of difference has been conducted within the framework of RFT. As described in Chapter 3, RFT describes derived relational responding as involving three generative properties: mutual entailment, combinatorial entailment and transformation of stimulus function. Mutual entailment refers to the fact that a relation in one direction mutually entails a relation in the other. For a frame of

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distinction, if A is different from B, then it can be derived that B is different from A. One empirical study relevant to mutually entailed arbitrary difference relations was provided by O'Connor, Barnes-Holmes and Barnes-Holmes (2011) who investigated relational responding in typically developing children and children with autism. In this study, contextual control was established for emitting either what was referred to as the *symmetrical* response (i.e., trained A1-B1, tested for B1-A1), or for emitting the alternative response, which was termed the *asymmetrical* response (i.e., trained A1-B1, tested for B2-A1; also see Boelens & van den Broek, 2000). While the cues used in this protocol were, accordingly, labelled in terms of symmetry and asymmetry, they might also be interpreted as “same” and “not same” respectively. In this series of experiments, children were first taught to emit textual (reading) responses (B) to text-based stimuli (A), e.g., saying “vug” when presented with the text card VUG (A1-B1) or saying “lup” when presented with LUP (A2-B2). They were then trained to select the symmetrically related (same) comparison when presented with the sample and a blue circle, and to select the asymmetrically related (not same) comparison when presented with the sample and a red circle. Thus, upon hearing “vug” in the presence of the red circle, the participants were trained to select the LUP text (B1-A2). The red circle plus “lup” as sample might thus also be described as evoking selection of “not lup”—that is, the one different from the sample.

Once contextual control was established over trained symmetrical (same) and asymmetrical (not same) relations, O'Connor et al. (2011) tested for generalization of contextually controlled relational responding to novel sets of stimuli. In these experiments, following training with textual responses, arbitrary matching of visual stimuli was established, and then contextually-controlled untrained (i.e., derived) relational responses were tested. While the typically developing children were able to generalize and demonstrate derived contextually-controlled relational responses to novel stimulus sets, not all the children with autism were able to do so. However, for these children, MET resulted in contextual control over the derived responses. As such, this could be described as an example of MET-based establishment of

contextually controlled mutual entailment of “same” and “not same” relational listener discriminations.

Combinatorial entailment refers to derivation based on the combination of two relations. For example, in the case of coordination, if $A = B$ and $B = C$ then $A = C$ and $C = A$. However, distinction is an unusual relation in this regard since for combinations involving distinction relations alone, the combinatorially entailed relation is unspecified: if A is different from B , and C is also different from B , then we cannot know the relation between A and C . Roche & Barnes (1996), for example, demonstrated that given relevant pre-training in arbitrary relations of same, different, and opposite among stimuli, participants would reliably select a cue (“?”) indicating that they did not know the relation between A and C if the pre-trained relations were such that $A \neq B$ and $C \neq B$. However, this situation applies only in cases of combinatorial entailment involving distinction relations alone. If relations of distinction are combined with relations of coordination, for example, then the entailed relations can be specified—for example, if A is same as B and B is different from C , then A is different from C and C is different from A .

In the first study to examine derived relations of distinction, Steele and Hayes (1991) taught typically developing teenagers to respond to arbitrary contextual cues (symbols). Participants were first taught to respond with respect to non-arbitrary relations of same, different, or opposite. Then, through a series of complex conditional discrimination training trials, they were taught to respond with respect to arbitrary versions of these relations. Subsequently, they were tested for derived relations of mutual and combinatorial entailment. Since this study involved a combination of relations, it was possible for all derived relations to be specified—for example, if A is different from B , and C is the same as B , then A and C are different. Across a series of experiments, all participants showed derived relational responding in accordance with these various frames. O'Hora et al. (2004) also demonstrated combinatorial entailment of relations including same/different (this time combined with before/after relations) with typically developing adults.

The third generative property of derived relational responding referred to above is transformation of functions. This refers to the empirically demonstrated fact

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that the functions of a stimulus can be influenced by its being in an arbitrary or derived relation with another stimulus. In the case of difference, if B is in a relation of difference with A and A has some function then it might be predicted that B will not have that function or will have a different function (Hayes, Barnes-Holmes & Roche, 2001, p. 36). For example, if I describe A as a person who likes country music and I say that B is different from A then it might be expected in the context of the conversation that B will not like country music. There is little or no research focused specifically on transformation of functions through difference. However, Chapter 8 presents the research conducted as a part of this thesis with children with autism, in which transformation of food preference functions through same and difference relations were assessed and trained. More specifically, children were first trained in arbitrary relations of sameness and difference of food preference of different animals (e.g., “the lion likes the same food as the bear but different food from the zebra”). They were then assessed for derived relations (e.g., “does the bear like the same as or different from the zebra?”) and transformation of functions through derived relations (e.g., given pictures of ice cream and chocolate as selection options, and the information that the bear likes ice cream, the task might be to specify what the lion likes and what the zebra likes).

Procedures for training and testing frames of distinction. While there is no previous research investigating how to establish frames of distinction when individuals are not able to demonstrate such responding, there are a number of studies that have developed procedures which may be beneficial in providing MET in relational patterns of distinction. These also suggest that learning history is an important factor in the demonstration of such relational responding. In evaluating what they referred to as the precursor to the Relational Evaluation Procedure (pREP), Cullinan, Barnes-Holmes and Smeets (1998, 2000, 2001) examined a variety of response options for training baseline relations through successive presentation of stimuli, including go/no-go (i.e., press the space bar if the stimuli go together, or don't press if the stimuli do not go together), different abstract stimuli (i.e., select a textual stimulus showing “!!!!” if the stimuli go together, or “*****” if they do not), “yes”/“no” textual stimuli, and “same”/“different” textual stimuli. In

these investigations, Cullinan and colleagues (2001) found that while all participants readily learned the baseline relations using a wide variety of response forms, derived responding was readily demonstrated only when the response requirement was to specifically select the words “same”/“different” (as opposed to the abstract symbols, space bar, etc.). These findings suggest that these cues tapped into participants’ pre-experimental histories in ways that other response forms did not. Subsequent MET with the abstract contextual cues and non-arbitrary relations did allow the arbitrary derived relational responses to come under the control of the other, abstract cues.

Empirical work using the pREP provided the foundation for the development of the Relational Evaluation Procedure (REP; see e.g., Barnes-Holmes, Hayes, Dymond & O’Hora, 2001). As the name suggests, the aim of the latter is to train and test participants to evaluate stimulus relations (both non-arbitrary and arbitrary). First, arbitrary shapes are established as contextual cues for particular relations (e.g., same, different) by training participants to select these shapes in the presence of particular pairs of non-arbitrarily related stimuli (i.e., relational tacting). For example, the participants might be trained to choose a shape designated as “same” in the presence of two similar stimuli and to choose a shape designated as “different” in the presence of two dissimilar stimuli. Typically (though not always) the functions of “yes” and “no” are next established in two further arbitrary stimuli by training participants to choose one or the other as appropriate in the presence of one or other of the cues already trained (e.g., “same” or “different”) juxtaposed with pairs of stimuli in corresponding or non-corresponding non-arbitrary relations. For example, if presented with the cue for “different” juxtaposed with a pair of similar stimuli then participants would be trained to choose the “no” cue, while if presented with the same cue juxtaposed with a pair of dissimilar stimuli then they would be trained to choose the “yes” cue. Once these symbols have been trained with non-arbitrary stimuli, the REP is then used to test relational tacting in totally arbitrary relational networks varying from simple to relatively complex. For example, Stewart, Barnes-Holmes and Roche (2004) used the REP to demonstrate and investigate networks of arbitrary same/different relations in their investigations of analogical reasoning, while O’Hora, Barnes-Holmes, Roche and Smeets (2004) used it to train participants

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to tact arbitrary same/different and before/after relations in their investigation of instructional control (see also O’Hora, Barnes-Holmes & Stewart, 2014).

A more recent evolution of the REP known as the Implicit Relational Assessment Procedure (IRAP; see Barnes-Holmes, Barnes-Holmes, Stewart, & Boles, 2010), which requires relational responding under time pressure, has facilitated even more subtle investigation of particular aspects of arbitrary same / different relational responding. The IRAP is similar in format to the REP but has participants respond to relations between natural language stimuli through time-pressured selection of natural language cues (i.e., the actual words “yes,” “no,” “same,” “different,” etc.) (see Figure 7.5 for examples). In one study, for example, this procedure was used to show a correlation between speed and flexibility of same/different relational framing and intelligence as measured by a standardized intelligence quotient (IQ) test (O’Toole & Barnes-Holmes, 2009). In this study, participants were presented with “same/different” and “before/after” tasks in which they were to answer “true” or “false” to pairs of stimuli congruent with a particular relation, such as answering “true” when presented with “table-different-cat.” They were also presented with tasks in which correct answers were incongruent with the stated relation—such as answering “true” when presented with “table-different-desk.” On all tasks, latency from the appearance of the stimuli to the response was the dependent variable. In addition, a difference score was calculated by subtracting the latency on congruent trials from the latency on incongruent trials and relative performance on the two was used as a measure of participants’ flexibility of relational responding (i.e., their capacity to fluently come under different forms of contextual control as required by the task). Results showed that, consistent with previous work, latencies on “same/different” trials were significantly less than on “before/after” trials, which coheres with the idea of “same/different” relations as being established earlier in language development than “before/after” (temporal) relations and thus being at greater strength. They also found that the difference score for “same/different” trials was greater than for “before/after”, indicating that reversing the relation was more difficult for this likely more strongly-established repertoire. Latencies for both types of “same/different” tasks as well as difference

(flexibility) scores were correlated strongly with IQ as measured by the Kaufmann Brief Intelligence Test. Difference (flexibility) scores for both types of relations were strongly correlated with the verbal subtest in particular, suggesting that training relational flexibility, not simply accuracy of relational responding, might be critical for improving language skills and promoting intelligent behavior.

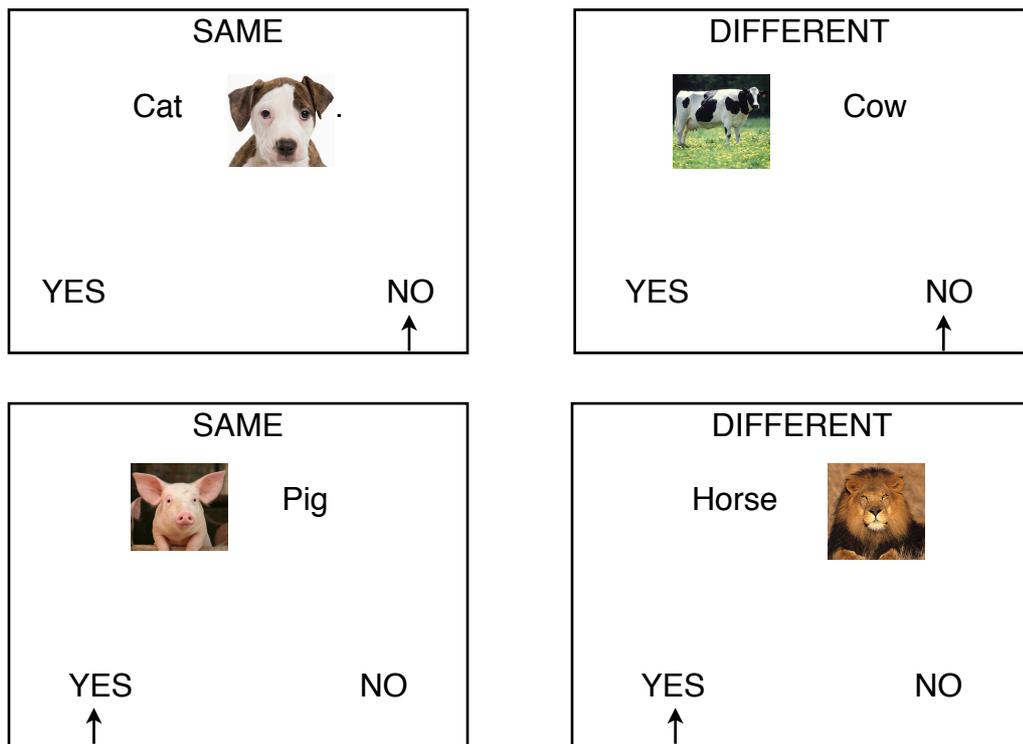


Figure 7.5. IRAP-type relational responding tasks. Tabletop versions could use text cards for the names, and the teacher could ask the relevant question, e.g., “Are they different?”.

Applied research on frames of distinction. As mentioned earlier, distinction is a different type of relational framing from sameness and thus training it allows additional opportunities to derive relations. Distinction is important in itself but by training two types of relational responding one also facilitates the possibility of training flexibility over contextual control to an extent that one cannot when only one pattern of arbitrary relations is in the repertoire and, as suggested by the research just reviewed, flexibility appears closely related to intellectual performance. Apart

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from this, the combination of both sameness and distinction is necessary as a precursor skill to more complex types of skills such as arbitrary hierarchical relations which facilitate categorization (as will be discussed further in Chapter 9). Recent work investigating training and improving fluency on relations of distinction in combination with relations of coordination (sameness) provides an excellent example of the importance of such training. Newsome et al. (2014) argue that arbitrary relational responding is critical to reading comprehension, and that responding in terms of both distinction and coordination is foundational for skills such as comparing and contrasting, making predictions, and integrating concepts found in text. In this study, explicit training was provided in relating stimuli on the basis of similarity or difference. Following training in identifying the categories, features and functions of a variety of common stimuli, participants were next trained in several different relational tasks involving distinction and coordination. For example, participants might be asked to identify how a bus and a dog are the same or how they are different. Participants were also asked questions about activities, such as “How is playing in the park like [*or* different from] swimming in the pool?” They found that this training package improved both responding to similar relational tasks with novel stimuli, and additionally improved performance on standardized measures of reading comprehension.

Directions for future research. There is now at least some evidence for contextually controlled arbitrarily applicable relational responding within frames of distinction including at a combinatorially entailed level (see also Dymond & Roche, 2013). However, much additional work remains. For example, there has as yet been little or no investigation of combinatorial entailment of distinction relations alone (though see Quinones & Hayes 2014). Perhaps more importantly with respect to the applied arena, there is as yet no published research on how to teach individuals relational framing in accordance with distinction when this skill is absent. Research will, however, be presented in the next chapter on the effectiveness of a MET protocol for training DRR in combined frames of coordination and distinction.

Most research into derived relations with very young children and children with developmental delay has focused on derived sameness (i.e., stimulus

equivalence). More work is needed to examine the stage at which relations of distinction tend to emerge in typically developing children and on methods for training such relations when they are absent. Determining the necessary non-arbitrary prerequisite skills would be beneficial just as a start, as well as potential prerequisites in terms of derived relational responding in frames of coordination (or other frames, such as opposition). There is also much work to be done to determine how relational responding in frames of coordination and distinction interact with the development of other frames, including hierarchy or categorization, and how best to promote flexibility of relational responding. These are among the issues that are investigated further in the next two chapters.

Implications for clinical practice. As noted, there is little research to establish an empirical basis for making recommendations about how to establish a repertoire of arbitrary relational responding in frames of distinction (either alone or combined with coordination or other frames) when such a repertoire is absent. Nonetheless, Luciano, et al. (2009) make a number of general suggestions for teaching the earliest frames of relational responding, including coordination and distinction, which would apply here, and which would benefit from investigations as described above. These include the use of MET in the specific pattern of relational responding as well as mixing different relations to improve flexibility, the use of specific and consistent cues for the relations being trained, and beginning with non-arbitrary relations before transitioning to arbitrary relations.

The results of O'Connor et al. (2011) with respect to symmetrical/asymmetrical responding would certainly suggest that MET in the relevant relational patterns may be successful. Establishing arbitrary conditional discriminations with respect to “yes/no” responding might also be important. Procedures similar to those used in the REP and IRAP with respect to “yes/no” responding as related to pairs of stimuli and names of relations (same/different) might usefully strengthen this repertoire. For example, one might present a picture, text stimulus, and a same or different stimulus, and require a “yes/no” response—for instance, if a picture of a cat is paired with the text DOG and the word DIFFERENT appears also (or the student is asked, “Are they different?”), then the required response would be “yes”. Training

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in second order contextual control over the arbitrary relations (e.g., “same” or “different” according to specified features, functions, or categories, and identifying how stimuli are the same or different) will also likely help strengthen and increase the flexibility of this repertoire (Newsome et al., 2014). For example, a game might be devised with key vocabulary words (such as from passages in a remedial reading text), and the teacher might ask the student to sort them in particular ways or identify how they are related. Given a selection of animals, questions might include finding something that lives in the same/different place as another, or has the same/different number of legs, and so on.

Beginning with familiar stimuli, and establishing new, arbitrary relations under the contextual control of cues for “same/different”, and testing for transformation of function might also provide a foundation for the more complex relational responding required at the level of deriving responses in frames of distinction. Such training might proceed following training with pictures and their names as described previously, but will also ensure that responding is occurring on the basis of the contextual cues and not some other form of stimulus control. The previously described animal food preference protocol and the research presented in the next chapter provides an example. In this protocol, responding must be under the control of the contextual cues of “same” or “different” in order to be consistently correct.

As individuals gain skills with arbitrary conditional discriminations and transformations of function in accordance with taught relations of same and different, MET may then proceed in the patterns of mutual and combinatorial entailment for relational framing in accordance with distinction. At first this is likely best accomplished in combination with coordinate relations, since, as previously discussed, identification of a relation as unspecified is relatively difficult (even for typically developing adults; see for example, Vitale, Barnes-Holmes, Y., Barnes-Holmes, D., & Campbell, 2008). For instance, the food preference protocol described earlier, and discussed further in the next chapter, involved testing correct derivation of an untrained food preference based on the combination of same and difference relations. One more advanced test within this protocol might be to look

for the combination of difference relations. For example, if the lion likes different food from the zebra and the zebra likes different food from the frog, then the student could be asked whether the lion and the frog like the same or different. Another way of proceeding might of course be to look for generalization of either combined same/different or different/different relations to a novel context; for example, one could teach that a cow and a horse live in the same place, but a cow and an axolotl live in different places, and then ask if a horse and an axolotl live in the same place or in different places.

Relational matching: Analogy

Finally, this literature review concludes with an examination of relational matching as that skill pertains to responding in accordance with arbitrary relations of difference. In explorations of analogical reasoning, relating *non*-equivalence to non-equivalence relations is relevant to responding in a frame of distinction. For example, as described previously in Chapter 3, the participants in the study by Barnes, Hegarty and Smeets (1997) first derived combinatorially entailed relations, and then related pairs of stimuli that were derived as arbitrarily the same (equivalent) to each other, and pairs of stimuli that were derived as arbitrarily different (non-equivalent) to each other. Stewart et al. (2004) used the REP to model the same phenomenon, that is, analogical reasoning as relating derived relations. In this case, participants had to select cues previously established as “yes” or “no” to evaluate whether or not the relation between two pairs of stimuli were correctly identified as being “same” or “different.” For example, given the pairs B1C1 and B2C2 and the cue “same,” the correct response would be “yes” (both pairs show equivalence relations and hence are the same as each other), while given the pairs B1C2 and B3C4 and the cue “different,” the correct response would be “no” (both pairs show a non-equivalence relation and hence show the same relations as each other).

Recently, Quah (2013), also working with typically developing adults, also combined the use of relational tacting with analogy procedures. In this study, participants were trained to tact abstract stimuli in arbitrary equivalence relations with a common name and then trained to tact the relation between A-B and B-C pairs

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of stimuli as “same” (e.g., A1B1) or “different” (e.g., B1C2). Following this training, participants were able to tact the untrained A-C pair relations as “same” or “different” as well as perform the relevant untrained relational matches (e.g., A1C1 to A2C2 or A1C2 to A2C1).

Directions for future research. There are a number of directions for future research as regards difference relations in the context of analogy. The work modeling analogy using derived relations that has been done thus far has concentrated on relations either between derived relations of equivalence or non-equivalence. However, in these cases, relations of *difference* were not trained (nor tested) prior to analogy testing. One obvious path extending on previous work might be to explicitly train and test relations of difference as well as sameness and examine if this might have facilitative effects on readiness to show analogical relations. Such work might be conducted with both typically developing adults and children. In addition, by examining not just relations of sameness between relational networks (e.g., A-B same as C-D) but also relations of distinction between such networks (e.g., E-F different from G-H) the work on relations between relations might be extended beyond traditional analogy to “quasi-analogical” relations. Furthermore, there is already work on the correlation between analogy and IQ. Such work might be extended by examining proclivity to show or to learn quasi-analogical relations. Finally, most of the work carried out so far as well as the suggestions just made refer to typically developing individuals. However, this research provides an important foundation for work with populations with developmental delay.

Implications for clinical practice. Stewart, Barnes-Holmes and Weil (2009) describe protocols for assessing and training analogy on the basis of equivalence relations that might be used to establish analogical responding with individuals who do not yet demonstrate such skills. These protocols proceed from training baseline conditional discriminations (e.g., A1-B1, A2-B2, A1-C1, A2-C2) to training and testing both matched (e.g., A1B1-A2B2) and unmatched (e.g., A1B2-A2-B1) pairs of stimuli, and then testing for derived relational responding for both matched and nonmatched pairs (e.g., B1C1-B2C2, C1B2-C2B1). In line with these recommendations, matching pairs of stimuli that have been trained in arbitrary

relations of either “same” or “different” might be an important step in teaching frames of distinction as well as establishing analogy. For example, if a student is taught to identify sets of animals as liking particular foods (e.g., the bear, lion and tiger all like popcorn, and they like different food from the giraffe, zebra and elephant, who all like cake) a task might be to match on the basis of whether particular pairs of animals represent the same relation. For example, a pair composed of the lion and bear should be matched to a pair involving the giraffe and zebra rather than a pair involving the tiger and elephant. This type of activity could be done first with taught relations as the elements making up the pairs, and subsequently with derived relations in the pairs. Again, research is necessary to determine an appropriate sequence of such training in relation to the other skills described in this section as well as to determine the most effective set of procedures for establishing this repertoire when it appears to be absent.

Conclusions

As noted earlier, comparing/contrasting and identifying similarities and differences are prevalent in curricular standards, and teaching activities that focus on these skills have been singled out as having particularly important impacts on academic performance (Marzano et al., 2001). In addition, recent research supports the importance of same/different relational responding in various contexts. Performance on relational tasks that include same/different derivations has also been correlated with the vocabulary and arithmetic subtests of the Wechsler Adult Intelligence Scale — Third Edition (O’Hora, Pelaez, & Barnes-Holmes, 2005) and with the verbal subtest of the Kaufmann Brief Intelligence Test (O’Toole & Barnes-Holmes, 2009), and activities that capitalize on deriving arbitrary relations of sameness and difference have been shown to improve reading comprehension (Newsome et al., 2014). O’Toole and Barnes-Holmes (2009) further suggest that ability to fluently respond to congruent and incongruent relations under contextual control may be a key indicator of relational flexibility, which has itself long been regarded as a critical component of cognitive ability (e.g., see Premack 2004). Similarly, Quinones and Hayes (2014) suggest that learning histories with respect to

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same/different responding can influence responding given an ambiguous relational network, and hence play an important role in psychological flexibility.

In this chapter, it is argued that by conceptualizing same/different responding as a continuum of responding from non-arbitrary to arbitrary within a frame of distinction, a path becomes clear for curriculum development and research on a likely hierarchy of component/composite skills as well as teaching procedures. Clearly, considerable research is warranted to investigate the influence and optimal sequencing of these skills and the most effective teaching procedures for establishing each of them. The work in the next chapter represents the first experimental exploration of how best to establish DRR in frames of distinction, a repertoire that appears to be important to language development as well as many academic skills and cognitive development more generally.

In summary, this chapter used an RFT theoretical framework to organize existing literature on same/different relational responding from comparative psychology, experimental behavior analysis, applied behavior analysis using a Skinnerian analysis of verbal behavior, and RFT itself. Furthermore, suggestions for teaching same/different responding were made based on this structure. However, there are clearly many gaps to be filled, as there is very little applied research with humans who are not yet able to demonstrate responding in accordance with difference, and little in the way of manualized curricula that advise on how to teach difference responding to children with autism. As Rehfeldt (2011) has also noted, it is critical for the field to move beyond relations of sameness and apply the derived relational responding paradigm to other relations if we are to develop practical teaching procedures for the many complex language and cognitive skills that are necessary for academic success. The next chapter represents the beginning of such a line of research, as early emergent repertoires of DRR in combined relations of coordination and distinction are explored.

Chapter 8:
Establishing Derived Relational Responding in Patterns of
Coordination and Distinction

Portions of the material in this chapter are in preparation for journal submission as:

Ming, S., & Stewart, I. (in preparation). Teaching the meaning of “different”:
Establishing derived relational responding in patterns of coordination and
distinction

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As discussed in the previous chapter, the identification of similarities and differences between stimuli or concepts has been recognized as a key skill in terms of development and academic success. Early same/different responding has been identified as an important behavioral cusp (McIlvane et al., 2011), while comparing/contrasting based on similarities and differences features prominently in academic curricula and benchmarks from preschool (e.g., California Department of Education, 2008) through advanced grade levels (e.g., National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Furthermore, teaching these skills has been highlighted as beneficial both in terms of student achievement generally (Marzano, Pickering & Pollock, 2001) as well as with respect to particular skills such as reading comprehension (K.B. Newsome, Berens, Ghezzi, Aninao, & W.B. Newsome, 2014). At the same time, however, there has been very little behavior analytic research into or evidence-based protocols for teaching these skills to children with autism. Hence, the next frame examined in this thesis was distinction, following on from the work presented in Chapters 5 and 6 on assessing and establishing frames of coordination. In line with the aim of the thesis to further the research on early emergent patterns of DRR, the work in this chapter explored the assessment and training of DRR in combined relations of coordination and distinction.

As discussed in previous chapters, Relational Frame Theory (RFT; Hayes, Barnes-Holmes, & Roche, 2001; Dymond & Roche, 2013) views responding in terms of sameness (coordination) and distinction as forms of relational responding. While such responding is rooted in non-arbitrary (physical) properties, it ultimately becomes abstracted from these roots as contextually-controlled arbitrary relational responding. RFT further argues that deriving arbitrary relations based on contextual cues (known as *relational framing*) is the heart of generative language, and these elements—arbitrary relations, contextual control, and derivation—are all critical to the work presented in this chapter. As discussed in the previous chapter, arbitrary relations (as opposed to non-arbitrary) are based on social or conventionally defined

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distinction. Such responding is also not based on physical properties but instead is under the control of a cue for a specific relational pattern. For example, if you know that my friend Bob likes the same music as I do, and you find out that my friend Sue likes different music than me, you would be able to derive that Bob and Sue like different music. I don't have to play you any of the music involved, or show you Bob and Sue for you to be able to answer a question about their musical tastes. Your response in this case is obviously not based on physical properties but instead is based on a previously learned pattern of responding based on the cues (i.e., “same” and “different”) involved. If given two possibilities for musical tastes and told what music one of us liked, you would also be able to identify what music the others liked based on these relations. If you could not answer such derivational questions, one might say that you don't “understand” the “meaning” of same/different—one might even say that you are responding “rotely” and just repeating what I told you. When children with autism are described as having “rote” responses, at issue may be the possibility that they have learned a variety of conditional discriminations (e.g. tacts for common items, intraverbal responses to questions such as “name some animals that live on a farm”), but that they cannot derive new relations on the basis of these taught responses: in other words, their language repertoire lacks *generativity*.

Relevant to the current focus, a few recent studies, as discussed in the previous chapter, have begun to examine repertoires relevant to deriving arbitrary same/different relations. For example, in the study by O'Connor, Barnes-Holmes and Barnes-Holmes (2011), typically developing children and children with autism were taught to respond under contextual control for either a *symmetrical* response or an *asymmetrical* response, either with abstract text stimuli (e.g. LUP) or with familiar stimuli (e.g. a cup). While all the typically developing participants were able to emit the derived responses with novel stimulus sets, a number of the children with autism were able to do so only following MET. Dunne, Foody, Y. Barnes-Holmes, D. Barnes-Holmes and Murphy (2014) worked with two children with autism to test their performance on tasks that required deriving relations of same/different using arbitrary abstract stimuli. In this study, the participants were required to respond “yes” or “no” to questions about the derived relation of difference or sameness. One

of the participants was able to demonstrate the derived AC relations without further training, while the second received extensive training on the AC relations and was then able to demonstrate derived relations with a novel stimulus set.

Both these studies suggest the potential of training same/different responding. However, further work is needed to more fully explore this domain. For example, the asymmetrical responding studied in O'Connor, Barnes-Holmes & Barnes-Holmes (2011) can be seen as related to same/different in that the contextual control over the asymmetrical response might be similar to a cue for “not in a relation of sameness”. However, this study did not set out to examine derived different relations specifically, which at the level being tested would in fact be symmetrical (if $A \neq B$ then $B \neq A$). Dunne et al. (2014), on the other hand, did study derived same/different relations, but this study trained only one participant, which limits the ability to generalize from the results. In addition, neither study used stimuli or instructional contexts that might be expected to facilitate generalization of the behavior being trained to more conversational or academically relevant skills, and neither in fact tested for any generalization beyond the highly abstract experimental task.

Hence, the studies in the current line of research were designed to address some of these deficits by providing a controlled demonstration of the effect of MET intervention, within a meaningful context, on derived same and different relations, and by including a test for generalization of this pattern to an academically relevant context. In these studies, an RFT-inspired protocol to assess and train relational framing in accordance with same and different in individuals with ASD was developed and tested. For this purpose, a game was designed involving animals and the foods that they liked. In this game, students are first taught that animal B likes the same food as animal A, but different food from animal C. They are then told which kind of food (from a choice of two possibilities) either A or C likes and have to say which food each of the other two likes. While this task may appear somewhat artificial, it controls for any previous history with the stimuli while also allowing a focus on learning only the new relation (who likes what) rather than having to teach any facts of novel stimuli (and anecdotally, the children also enjoy the novelty of the task). Furthermore, the task is in fact similar to topics of conversation and classroom

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“polls” common to early childhood education, such as which members of the class have particular holidays, activities, or food as their “favorite”.

The first protocol developed was based on a traditional match-to-sample format, with two sets of stimuli, designated A1, B1, and C1, all of which “liked” food 1, and A2, B2, and C2, all of which “liked” food 2. Relations were first trained such that $A1=B1$, $A1\neq B2$, $A2=B2$, $A2\neq B1$, and then these relations were tested for mutual entailment. Subsequently, C-B relations were trained, and then A-C relations ($A1=C1$, $A2=C2$, $A1\neq C2$, $A2\neq C1$) were tested. Using this format, one student was unable to learn the baseline conditional discriminations. She was then tested further and it was determined that she was not able to demonstrate non-arbitrary same/different relational responding. A second student was able to learn all the baseline conditional discriminations, and subsequently passed both mutual and combinatorial entailment testing. However, it took more than 250 trials to train the initial conditional discriminations, and this student requested frequent breaks despite appearing to enjoy the game initially.

After this initial work based on a more traditional match-to-sample format, it was determined that (a) non-arbitrary relational responding skills should be tested thoroughly prior to arbitrary responding (and non-arbitrary training might be a useful component of any arbitrary training protocols), as well as that (b) a more streamlined method of training initial baseline relations was needed. An assessment and training protocol was thus developed using a grid format in which animal stimuli were placed in one column, and food stimuli could be placed in the next column. This format also required fewer conditional discrimination relations to be trained, as will be described below. Non-arbitrary testing was incorporated, as well as re-exposure to non-arbitrary training and testing when arbitrary tests showed inconsistent results. The development of these protocols will be described next in two case studies, followed by a systematic evaluation of the final protocol using a concurrent multiple baseline design with two children with autism.

General Methods

Materials

The *Training and Assessment of Relational Precursors and Abilities* (TARPA; Moran, Stewart, McElwee & Ming, 2010, 2014; Moran, Walsh, Stewart, McElwee & Ming, 2015) was presented on an Apple iPad™ for baseline assessment and intervention. Stimuli used in the TARPA protocol consisted of one inch square pictures of common animals, and one inch square pictures of common foods (see Figure 8.1 for the layout of the task on the iPad). Stimulus sets were selected by the program from a database set on a quasi-random basis so that previously used stimuli did not appear again for several presentations and even when they did they appeared in novel combinations.

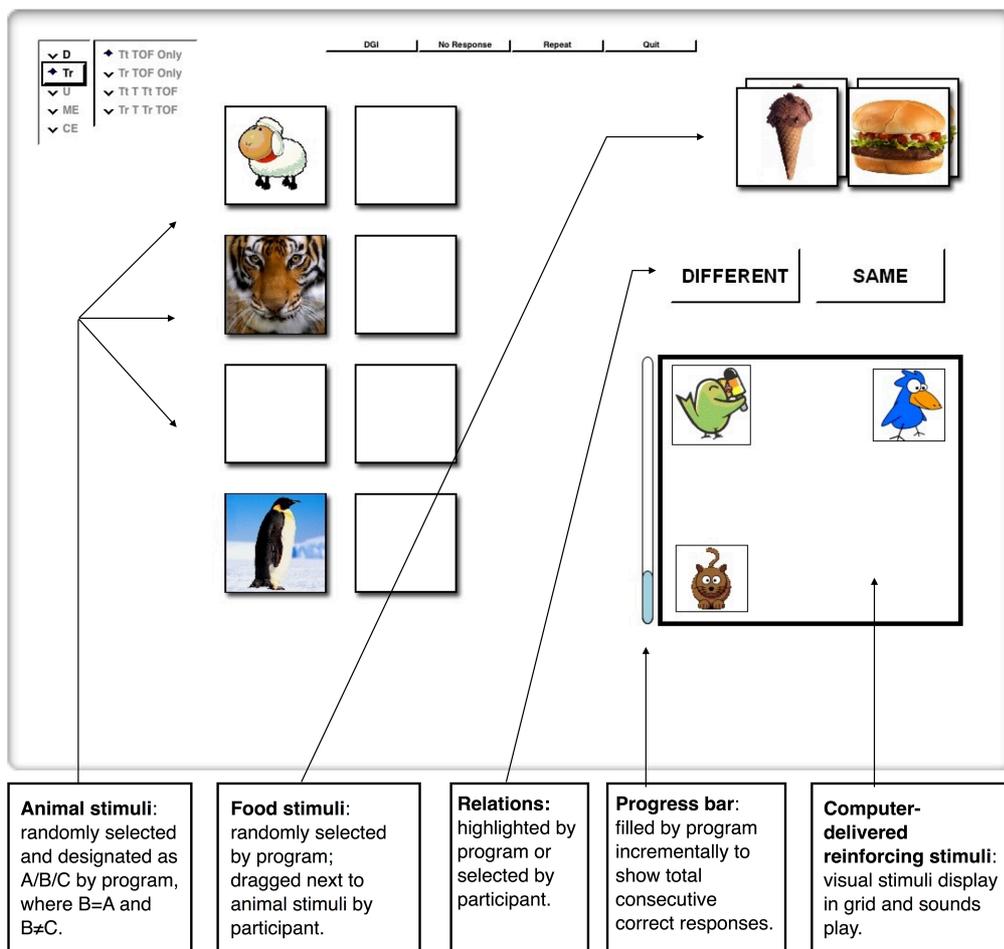


Figure 8.1. Layout of the stimuli in the same/different animal game in the TARPA.

Data Collection

Dependent variable. The dependent variable was accuracy of responding during first trial tests of derived responding following training in baseline conditional discriminations of SAME and DIFFERENT (see each specific study for training and testing procedures).

Interobserver agreement. Data on all trials in computer-based sessions were collected automatically by the TARPA program; thus, interobserver agreement (IOA), per se, was not collected for these sessions. However, the experimenter manually tracked whether or not each test in the program was passed or failed, to ensure the appropriate progression of training and testing in a session, for all sessions (see Appendix A). Electronic data files were then compared to session data for all sessions, with 100% agreement. IOA was collected by a second observer (the participants' teacher) for 25% of generalization testing trials, with 100% agreement.

Screening for Non-arbitrary Relational Responding

Prior to assessing for DRR, participants were screened using tests requiring selection of SAME or DIFFERENT items based on non-arbitrary (physical) relations (i.e., responding to the instruction, “find same/different” when presented with a sample and one identical comparison and one different comparison). Participants were also screened to ensure they could respond correctly on a non-arbitrary version of the game to be played. As detailed in Figure 8.2, in this game, the stimulus grid displayed animals in one column, and food items were placed next to them in the second column. The program then highlighted one of the animal stimuli and a cue for either SAME or DIFFERENT. The task was then to identify “who likes the same as/different from” the highlighted animal. If a participant could not successfully respond in this non-arbitrary game, training was provided prior to the initiation of baseline in the study. Training consisted of prompting the student to tact the food next to the highlighted animal, identify which food in the column was the same/different, and then select the animal next to that food. Correct responses were followed by praise and computer-delivered reinforcement (brief sounds, such as clapping, and a display of an array of small pictures of smiley faces, stars, etc.).

Training continued until the participant could respond correctly on 10/10 trials with a new stimulus set, for three consecutive stimulus sets.

Non-arbitrary same/different game

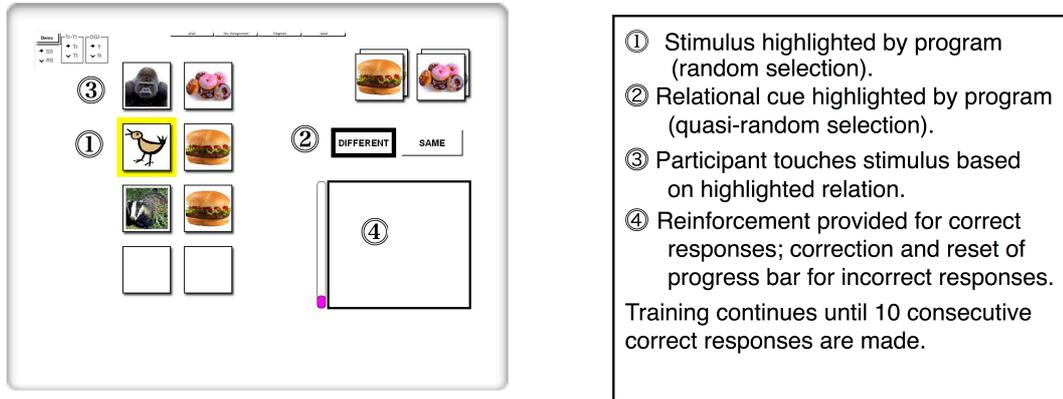


Figure 8.2. Non-arbitrary same/different game on the TARPA.

DRR Assessment Procedures

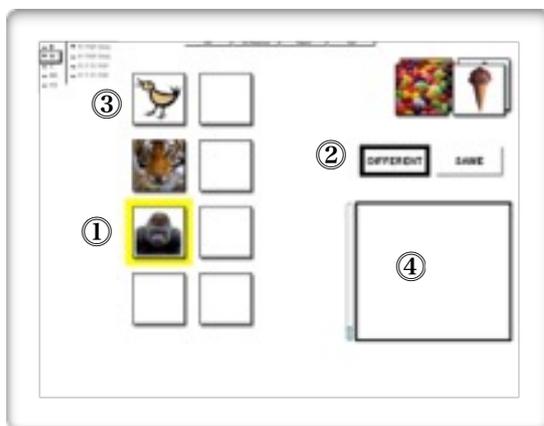
The procedures used for assessing DRR consisted of two parts, as detailed in Figure 8.3 and described below. For each trial, a new animal stimulus set was used and first the relations between animals ($B=A$, $B\neq C$) were trained using conditional discrimination training procedures and then the DRR test was conducted.

Assessment Procedures Step One: Initial conditional discrimination training. In all computer-based sessions, the administrator and participant sat next to each other at a table facing the computer screen. The program presented the animal stimuli in the first column of the grid, as shown in Figure 8.3, when the administrator touched each box, and then the program highlighted the designated B stimulus. The teaching procedure for initial conditional discrimination training then consisted of the administrator first *demonstrating* the correct response: touching the sample [B] stimulus, which resulted in the program highlighting one of the contextual cues [i.e., SAME or DIFFERENT], touching the cue, which then highlighted the correct comparison [i.e., A or C], which the administrator selected. The administrator also

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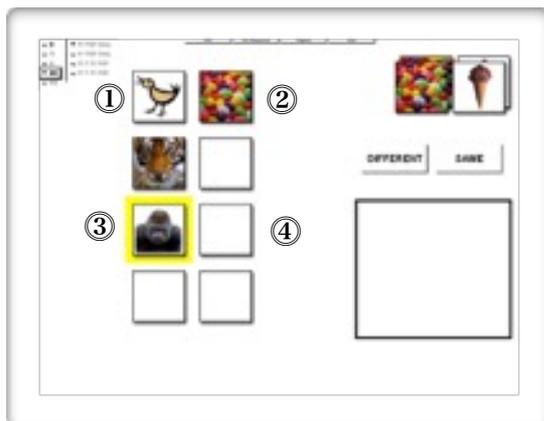
vocally described the relation in question as she touched each stimulus and cue (e.g., “The lion likes different food from the penguin.”). The participant then entered the conditional discrimination *training* component, as also detailed in Figure 8.3 (Step One). In this the participant first had to touch the sample (B), at which point either the SAME or DIFFERENT cue was highlighted (the relation varied quasi-randomly across trials); s/he then had to touch the correct comparison (A or C). The participant was also prompted to vocally produce the correct description of the relation (i.e., as previously modeled by the teacher).

Step One: Conditional Discrimination Training



- ① B stimulus highlighted by program; participant touches B stimulus.
 - ② Relation highlighted by program (quasi-random selection).
 - ③ Participant touches A/C stimulus and states relation (e.g., “The gorilla likes different food from the bird.”).
 - ④ Reinforcement provided for correct responses; correction and reset of progress bar for incorrect responses.
- Training continues until 10 consecutive correct responses are made.

Step Two: DRR Testing



- ① A/C stimulus highlighted by program (quasi-random selection).
 - ② Participant selects and drags a food stimulus next to highlighted animal.
 - ③ B stimulus highlighted by program.
 - ④ DRR test: Participant selects a food and drags next to B stimulus.
- Trial scored as correct/incorrect; no feedback provided. E.g., correct response given relation B (gorilla) \neq C (bird) is to drag ice cream next to gorilla.

Figure 8.3. Sequence of tasks for each trial in baseline assessment and post-intervention; each trial uses a new stimulus set for animals and a new stimulus set for food.

Correct responses were followed by praise and computer-delivered reinforcement as described for the non-arbitrary game. An on-screen progress bar became increasingly filled in to show how many consecutive correct responses had been made, and the student was told that s/he needed to “fill up the bar”. In addition, praise and tangible reinforcers (e.g., playing recreational games on the iPad) were delivered contingent on correct responding and completion of sections of the TARPA program during all training sessions on the schedule identified by the student’s classroom teacher as appropriate to a learning session. Incorrect responses resulted in the progress bar returning to zero (empty), and the administrator prompting the student to “try again” and prompting the correct response for the next trial. This training continued until the participant made 10 consecutively correct responses.

Assessment Procedures Step Two: Derived relational responding (DRR) testing. Once conditional discrimination training was completed, a DRR test was conducted, as shown in Figure 8.3 (Step Two). The DRR test consisted of first either the A (SAME as B; in the context of a SAME test) or C (DIFFERENT from B; in the context of a DIFFERENT test) stimulus being highlighted by the program (whether it was A or C varied quasi-randomly across stimulus sets), at which point the participant was prompted to select a food item that that animal liked by dragging it from its original placement to an empty box next to the animal stimulus. Once the food item was selected, the B stimulus was highlighted and the participant was instructed to select what food that animal liked. A correct response would then be to select the food item that was in accordance with the relevant relation (e.g., given a choice between jelly beans and ice cream, if A liked jelly beans, then B should like jelly beans because the B-A relation is SAME; if C liked jelly beans, then B should like ice cream because the B-C relation is DIFFERENT). No feedback was provided during DRR testing. Following completion of this test, a new animal stimulus set was presented, and conditional discrimination training began with new animals and new relations.

Study 8.1: Case study in the assessment of distinction

Once the same/different game protocol was developed, as described above, it was tested and further refined. One participant was involved in this protocol testing: Paul, who was involved previously in Study 5.1 (Single case investigations of context). At the time of this study on distinction, he was 9 years 8 months old.

Methods

All general methods with respect to materials, data collection, screening, and DRR assessment procedures were followed as described above for *General Methods*. The additional procedures used in the study consisted of assessment of DRR at the combinatorial entailment level as described below.

Assessment Procedures: Testing for DRR at the combinatorial entailment level. Following the assessment of DRR as described in the *General Methods* section above, Paul was next trained and tested for DRR at the combinatorial entailment level. As with the previously described assessment, there were several steps to this testing: first the relevant conditional discriminations were trained, which required training an additional relation following the arbitrary relations trained as described above. Once the B-same-as-A and B-different-from-C relations were trained, the A stimulus was removed, and a second animal that was designated as liking the same food as B was displayed, the D stimulus. Training on B-D and B-C relations proceeded as described previously for B-A and B-C.

Secondly, following training in selecting the correct stimulus given a specified relation with B, all four stimuli were displayed, and training on tacting the relevant trained relations was conducted. Two stimuli were highlighted, either A and B, C and B, or D and B, and the task was to then select the correct relation shown, either “SAME” or “DIFFERENT”; that is, the participant was trained in arbitrary relational tacting. Finally, once the participant responded with 6 consecutively correct relational tact responses, a DRR test was administered. For this test, either A, C, or D was highlighted (quasi-random selection), the participant selected a food that that animal “liked”, and then one of the remaining A, C, or D stimuli was selected. Thus, A-C/C-A (different), A-D/D-A (same), or C-D/D-C (different) relations were

tested. While not required, Paul preferred to fill in the entire grid following this initial test and was allowed to do so. Following the test for DRR, a new stimulus set was selected, and the process repeated.

Generalization. Tests for generalization were conducted using tabletop procedures. For these, two types of presentation were used, as will be discussed further below. Generalization tests using pictures consisted of the teacher essentially copying the layout of the TARPA, but on the table using laminated picture cards. Three animal pictures were placed in front of the student, with two stacks of food pictures to the side. The teacher demonstrated the relevant arbitrary conditional discriminations and had the student repeat them, then vocally asked the relevant DRR testing question.

Paul displayed a tendency to play with the pictures, making the animals eat different foods, and creating stories about them. This appeared to be impeding his performance on both conditional discrimination trials as well as DRR tests. Therefore, the presentation was changed to use text presented on the whiteboard, as Paul was a good reader. The administrator asked the participant what animals and foods he would like to talk about, and then the administrator wrote the animals and foods on the whiteboard along with a two sentence “story” describing the SAME and DIFFERENT relations (e.g., “The bear likes the same food as the lion. The bear likes different food from the tiger.”), which the participant then read aloud. Stimuli were coded as either A or C by the administrator for the purpose of ensuring that the appropriate relational task was presented, but the participant was never made aware of those codes. The participant was vocally asked the same types of questions as in the DRR tests conducted on the iPad: first to identify what food either the A or C animal liked, which the administrator then wrote next to the animal name, then what food the B animal liked and finally what food the remaining animal liked. The participant was required to respond vocally, and no feedback was provided with respect to the accuracy of responding. Once the DRR test was complete, the whiteboard was erased and the student was asked to name three more animals and two foods to talk about for the next test. A total of six tasks, three SAME and three

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DIFFERENT, were presented in random sequence. The full script for the tabletop generalization testing can be found in Appendix D.

Results and Discussion

Paul's results for the first phase of training and testing are shown in Figures 8.4 and 8.5. Non-arbitrary tests conducted during screening had previously indicated a robust repertoire of non-arbitrary same/different relations, both selecting correct stimuli based on their relation, as well as non-arbitrary relational tacting (i.e. stating that the two animals either liked SAME or DIFFERENT food). Initially, Paul was tested for DRR by selecting the food that A/C likes after selecting the food B likes (B likes food1, what does A/C like?)¹. Paul passed 30 out of 31 testing trials for same/different relations with this format of test, at which point, testing with the reverse relation began (A/C likes food1, what does B like). Paul again performed consistently well on DRR tests with same as well as different relations, passing 14 out of 15 test trials. Paul was then tested for DRR using tabletop testing procedures.

During tabletop testing procedures, Paul initially performed well when the "same" relation was tested, and did not consistently perform well when the "different" relation was tested (see Figure 8.5). However, after the first ten trials (five trials with each relation), he began to almost always select the "different" food. It appeared that he was responding on the basis of simply selecting the item that had not yet been picked, rather than on the basis of the trained same/different relations.

1. The initial analysis of this task assumed that it would be the easiest level of a DRR test in that it appeared to require deriving a single new response based on a single trained relation: if one were conducting conditional discrimination training in a more typical match-to-sample format as for equivalence testing, the training "direction" would be considered to be B→A and B→C and thus the test was set up as "B likes food 1, what does A/C like?". However, further analysis led to another conclusion. When training that "B likes different food from C", identifying what food C likes on the basis of B requires that one can also identify that "C likes different food from B"—that is, the opposite "direction" from training and an additional derivation requirement. Since the assessment was intended to ensure maximum support for any ability to derive the relevant relations, subsequent testing instead identified what food A/C liked and then asked what food B liked. If the participant passed this, then the other direction of testing could be conducted.

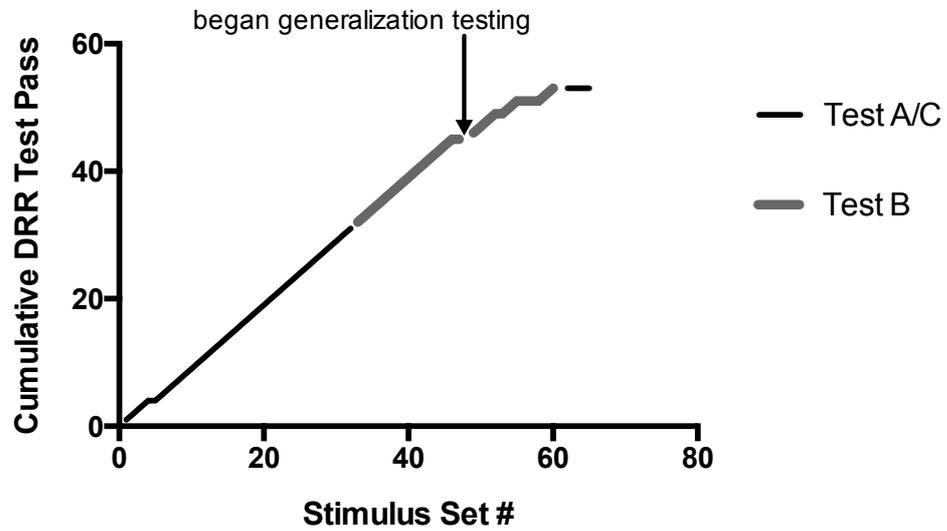


Figure 8.4. Results for Paul: Cumulative passes on tests of DRR during the first phase of assessment with the TARPA. Given two choices for each test, chance responding would be indicated by failing on average every other test.

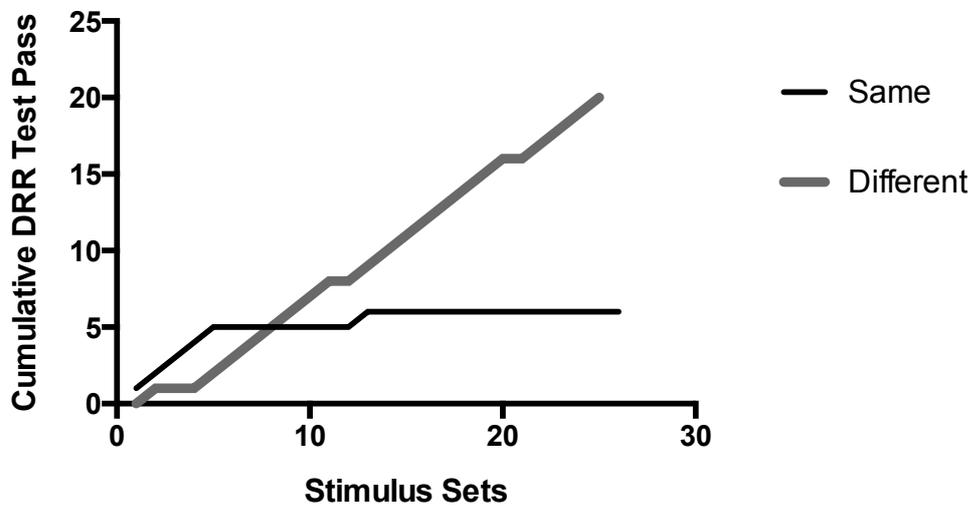


Figure 8.5. Results for Paul: Cumulative passes on tests of DRR during the first phase of topographical generalization testing. Given two choices for each test, chance responding would be indicated by failing on average every other test.

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Assessment using the TARPA was again instituted and Paul's performance was inconsistent, appearing most of the time to again be responding on the basis of selecting the not-yet-chosen food item, rather than on the basis of the trained relations. At this point, training and testing was continued, but with tracking of same/different test results separately. The results of this testing are shown in Figure 8.6. Given the importance of non-arbitrary relational responding that had been identified in earlier pilot work and the inconsistent results of testing, it was decided to provide additional training to strengthen Paul's responding on the non-arbitrary form of the task, as described in the *Screening* section above. He performed at 100% for three stimulus sets with non-arbitrary relations, and then was tested for arbitrary relations. He initially performed well, passing both "same" and "different" tests. However, on being assessed with the the topographical test, he appeared to return to his earlier pattern of responding with the "different" item only. He was then provided with re-exposure to the TARPA activity with non-arbitrary stimuli but without reinforcement, and again he was successful; however, once again on being returned to topographical testing, his pattern of performance remained as before. Re-training (i.e. with reinforcement) on the non-arbitrary task was again provided, and once again upon returning to topographical assessment he continued to respond by selecting the "different" item only. Paul then spontaneously began initiating his own version of the topographical game during a break in the session. He wrote out the story and the stimuli, and correctly performed the task independently and spontaneously. At this point he was re-tested on both topographical tests and with the TARPA, and performed successfully in all subsequent testing, including the more complex version at the combinatorial entailment level.

While it is difficult to identify why Paul was able to ultimately pass all the DRR tests once he began to initiate the game himself, it would appear that at minimum, exposure to the types of tests conducted in these protocols strengthened his repertoire and allowed him to generalize his skills. When conducting the assessment at the combinatorial entailment level, Paul did require training in relational tacting; that is, the conditional discrimination training alone did not result in him also being able to tact the relevant relations. Therefore, in the next case study,

in which an MET intervention was provided following failed assessment of DRR skills, a relational tact training step was included in the intervention.

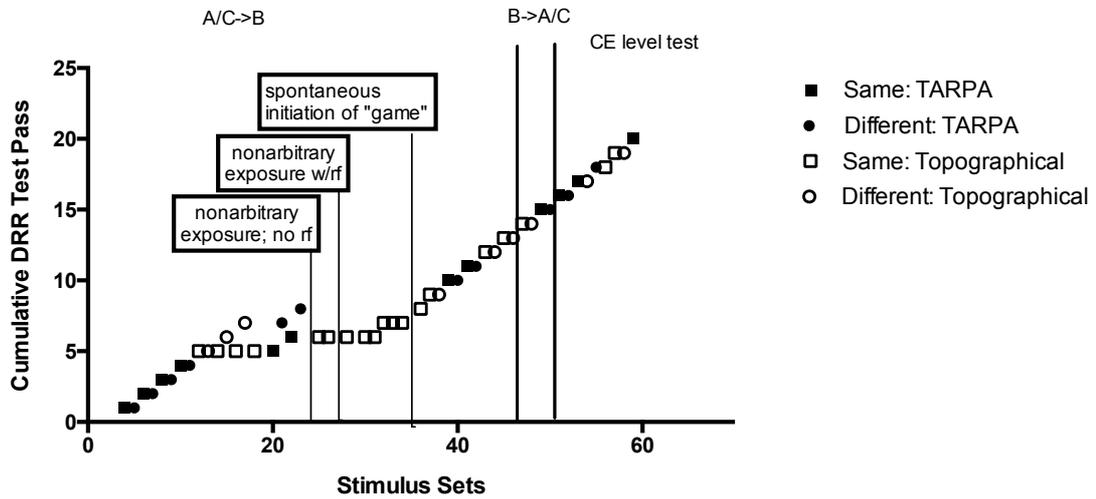


Figure 8.6. Results for Paul: Cumulative passes on tests of DRR during the second phase of assessment on the TARPA and topographical generalization testing. Given two choices for each test, chance responding would be indicated by failing on average every other test.

Study 8.2: Case study of MET for distinction

Following the development of assessment procedures as described above, an intervention using multiple exemplar training was developed and tested. For this case study, one student participated. Evan, age 17, had an independent diagnosis of ASD, and was enrolled at a school providing ABA-based 1:1 and group instruction following a VB approach. Evan had been involved in earlier pilot tests of the TARPA protocol (Stewart, McElwee, Ming & Burgess, 2010), and had passed tests of combinatorial entailment in frames of coordination. He did, however, require several sessions of training in the non-arbitrary form of the TARPA task for same/different, (as described above in the *Screening* section), prior to the initiation of this case study.

Methods

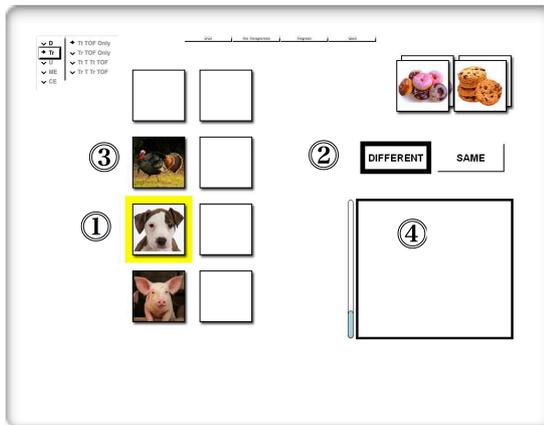
All general methods with respect to materials, data collection, screening, and baseline assessment followed the procedures as described above for *General Methods*. A pre-intervention topographical test using a whiteboard was conducted using the topographical generalization procedures described above in Study 8.1 for the text-based generalization test (also see Appendix D). Two multi-step intervention procedures were then used following baseline, as described below.

Intervention 1. The intervention phase was first conducted on the iPad, and consisted of the following procedures, as detailed in Figure 8.7 and described below. For each intervention trial a new animal stimulus set was used. First the relations between animals ($B=A$, $B\neq C$) were trained using conditional discrimination training procedures as in baseline. Next, the participant was assessed (and trained if need be) for responding to the relations between animals with an additional response topography—by tacting the relation rather than selecting a stimulus in accordance with the relation—and then DRR training was conducted using additional prompting procedures, as described below.

Intervention 1 Step One: Conditional discrimination training. The participant was first taught to select animals on the basis of same/different relations, using the same procedure as in the baseline assessment phase (described in the *General Methods* section above, and detailed in Figure 8.7 [Step One]).

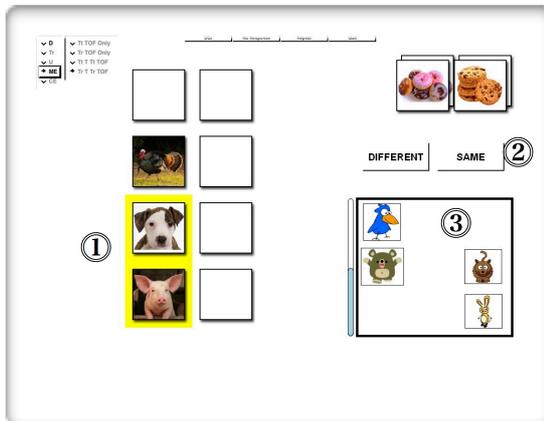
Intervention 1 Step Two: Relational tact training. In this step, as detailed in Figure 8.7 (Step Two), Evan was taught to tact the relation between pairs of animal stimuli. During this relational tact training, either the A and B or the C and B stimuli were highlighted and the participant was asked, “Do they like the same or different food?” In response, he was required to select the appropriate relational label (i.e., SAME or DIFFERENT). Reinforcement and correction procedures were the same as during conditional discrimination training, and training continued until six consecutively correct responses were made.

Intervention Step One: Conditional Discrimination Training



- ① B stimulus highlighted by program; participant touches B stimulus.
 - ② Relational cue highlighted by program (quasi-random selection).
 - ③ Participant touches A/C stimulus and states relation (e.g., “The dog likes different food from the turkey.”).
 - ④ Reinforcement provided for correct responses; correction and reset of progress bar for incorrect responses.
- Training continues until 10 consecutive correct responses are made.

Intervention Step Two: Relational Tact Training



- ① BA/BC stimulus pair highlighted by program (quasi-random selection).
 - ② Participant touches name of relation and states relation (e.g., “The dog and the pig like the same food.”).
 - ③ Reinforcement provided for correct responses; correction and reset of progress bar for incorrect responses.
- Training continues until 6 consecutive correct responses are made.

Figure 8.7. MET intervention steps one and two: Training relations between animal stimuli, for each trial with a new animal stimulus set.

Intervention 1 Step Three: DRR Training. Following the relational tact training, prompting was provided as needed to attend to the relations between the stimuli. Prior to the requirement to select which food the animal liked, the participant was prompted to tact the relation between the stimuli for the test, and then asked, “Which food is [SAME/DIFFERENT] from what [A/C] likes?” For example, if the participant selected that A liked food1, the administrator would prompt, “Do A and B like the same or different?” and then “Which food is the same as what A likes?” prior

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to the correct food item being selected; this pre-trial prompting was then provided for all subsequent trials in the session.

Intervention 1 Step Four: Fading. Following successful DRR training with pre-trial prompting, the pre-trial prompting was faded, and DRR was tested without feedback, following the relational tact training in the baseline relations.

Intervention 2: MET with food stimulus sets. Based on Evan's performance during Intervention 1, as will be described further below, an additional set of intervention procedures was developed, in which (following relational tact training), multiple exemplar training (MET) of correct derived relational responding was conducted, using multiple sets of food items. This was conducted using the selection of text on the whiteboard, as in the topographical testing prior to intervention.

In this intervention, conditional discrimination training and relational tact training were provided using text on the whiteboard, followed by a SAME or DIFFERENT test. During SAME and DIFFERENT tests, if an error was made then pretrial prompting was provided as above, and a new set of food items was written on the board, and another test was given with the new food sets, but with the same animal relations. Testing continued with the same set of animal stimuli until three consecutive correct responses with novel food sets were made, and then a new animal set was written, with new relations. The intervention continued until the participant completed three animal sets with all DRR tests correct.

Post-Test. Following Intervention 2, DRR testing was then conducted with the same procedures as described above for baseline and as shown in Figure 8.3.

Results

Results for Evan are shown in Figure 8.8. During baseline, Evan's performance was inconsistent and often appeared to be following the same pattern as Paul, with the more consistent selection of the food that had not yet been selected (the "different" food). Following baseline, Intervention 1 began. While Evan was successful when given pre-trial prompting, his performance returned to baseline levels when the prompts were faded, despite the continued use of relational tact

training prior to DRR testing. Intervention 2 was then begun, and Evan was successful in responding to the written tasks on the whiteboard. He was then successful in responding to DRR testing on the iPad using baseline procedures (i.e., without relational tact training).

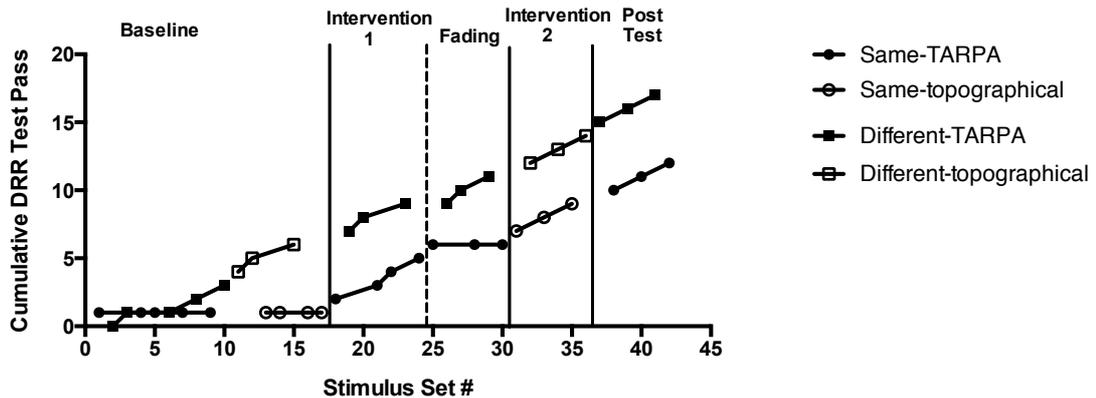


Figure 8.8. Results for Evan: Cumulative passes on tests of DRR tests for SAME and DIFFERENT on the TARPA and topographical generalization testing. Given two choices for each test, chance responding would be indicated by failing on average every other test. .

It was initially supposed that strengthening the trained relations through relational tact training might also allow Evan to derive the relevant responses, and it was only when that intervention was unsuccessful that MET using the food items was conducted. It was only following this MET intervention that Evan was able to demonstrate DRR. On the basis of these results, it was determined that an evaluation would be conducted of the full protocol used for Evan, including both the relational tact training and the MET with food items, which was subsequently developed for presentation on the iPad as will be described in the following study.

Study 8.3: MET protocol evaluation

Following the development and initial testing of the same/different assessment and training protocols as described above, a concurrent multiple baseline study was conducted to more systematically evaluate the effectiveness of the MET protocol as developed in Study 8.2 and subsequently developed for the iPad.

Methods

Participants and Setting. Two children with diagnoses of autism participated in the study. The participants attended a nonpublic school that provided small group instruction with a focus on speech and language needs. Isaac, age 12, had a Peabody Picture Vocabulary Test (PPVT) age equivalency score of 7-0. Ann, age 11, had a PPVT age equivalency score of 6-5. Both participants were able to pass derivation tests in a frame of coordination (equivalence), with auditory-visual relations. Both were also able to respond to the screening tests (as described in the *General Methods* section above) requiring selection of SAME or DIFFERENT items based on non-arbitrary (physical) relations (i.e., responding to the instruction, “find same/different” when presented with a sample and one identical comparison and one different comparison), including the non-arbitrary version of the game to be played as described previously, in which food items were displayed next to the animal picture stimuli and the task was to identify “who likes the same as/different from” a particular animal. Isaac readily succeeded in the non-arbitrary version of the game, while Ann required one session of training in this game prior to beginning baseline.

The study was carried out in a separate room at the school where the participants were enrolled. Sessions typically lasted 20-30 minutes and were generally held two to three times per week, barring absences for illnesses, school holidays, and participant and researcher availability, over the course of approximately two months.

Procedures. All general methods with respect to materials, data collection, screening, and baseline assessment procedures were followed as described above for *General Methods*. Generalization testing using a whiteboard was conducted prior to baseline and following intervention, using the generalization procedures described above in Study 8.1 for the text-based generalization test (see Appendix D). The intervention procedures were based on those developed in Study 8.2, which consisted of four steps (conditional discrimination training, relational tact training, MET with multiple sets of food stimuli, and then testing with a new stimulus set), as described below.

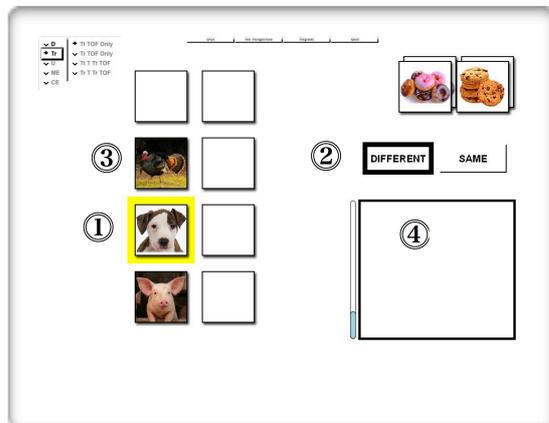
Intervention Phase Step One: Conditional discrimination training. As in the previous case studies, the participants were first taught to select animals on the basis of same/different relations, using the same procedure as in the baseline phase (see Figure 8.9).

Intervention Phase Step Two: Relational tact training. In this step, participants were taught to tact the relation between pairs of animal stimuli as described for Study 8.2 (see Figure 8.9). Reinforcement and correction procedures were the same as during conditional discrimination training, and training continued until six consecutively correct responses were made.

Intervention Phase Steps Three and Four: DRR training. Following relational tact training, multiple exemplar training (MET) of correct derived relational responding was conducted, using multiple sets of food items, similar to the procedures developed in Study 8.2. During DRR training, the first SAME and DIFFERENT tests were conducted as during baseline DRR testing, and detailed in Figure 8.10 below. Correct responses were followed by the same type of reinforcement as in other training procedures, and training continued with a different set of food items on each trial until six consecutively correct responses were made, at which point a new animal stimulus set was displayed and conditional discrimination training began again with a new set of relations. Two animal sets were trained (each with MET using multiple food sets) during each intervention session.

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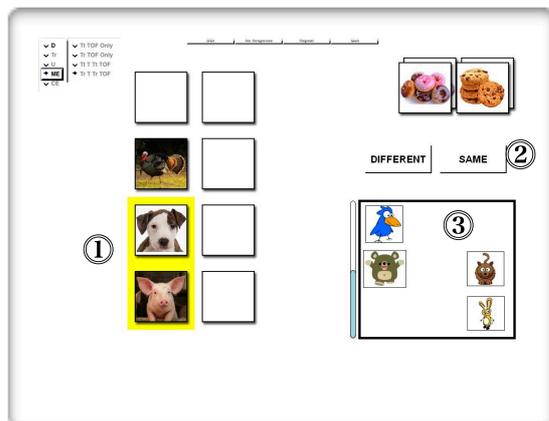
Intervention Step One: Conditional Discrimination Training



- ① B stimulus highlighted by program; participant touches B stimulus.
- ② Relational cue highlighted by program (quasi-random selection).
- ③ Participant touches A/C stimulus and states relation (e.g., “The dog likes different food from the turkey.”).
- ④ Reinforcement provided for correct responses; correction and reset of progress bar for incorrect responses.

Training continues until 10 consecutive correct responses are made.

Intervention Step Two: Relational Tact Training

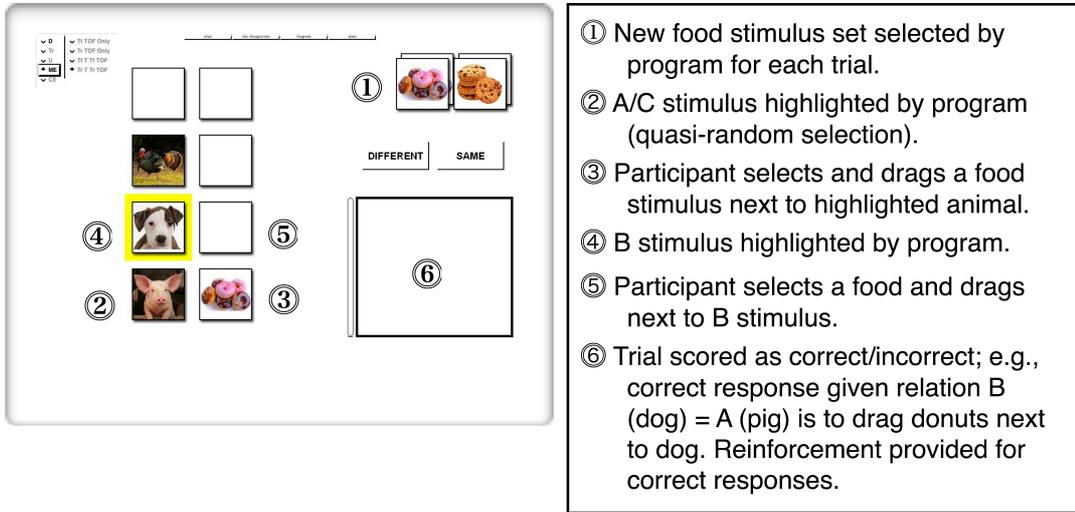


- ① BA/BC stimulus pair highlighted by program (quasi-random selection).
- ② Participant touches name of relation and states relation (e.g., “The dog and the pig like the same food.”).
- ③ Reinforcement provided for correct responses; correction and reset of progress bar for incorrect responses.

Training continues until 6 consecutive correct responses are made.

Figure 8.9. MET intervention steps one and two: Training relations between animal stimuli, for each trial with a new animal stimulus set.

Intervention Step Three: DRR Training



① New food stimulus set selected by program for each trial.

② A/C stimulus highlighted by program (quasi-random selection).

③ Participant selects and drags a food stimulus next to highlighted animal.

④ B stimulus highlighted by program.

⑤ Participant selects a food and drags next to B stimulus.

⑥ Trial scored as correct/incorrect; e.g., correct response given relation B (dog) = A (pig) is to drag donuts next to dog. Reinforcement provided for correct responses.

Figure 8.10. MET intervention step three: DRR training for the first trial for each relation and subsequent trials for relations on which no errors had been made. DRR training continued with new food stimulus sets until 6 consecutive correct responses had been made.

If the student dragged the food items to the wrong place then the program returned them to their original places, the experimenter said “Let’s try that again,” and the student was then prompted to tact the relation between the stimuli for the test, and then asked, “Which food is [SAME/DIFFERENT] from what [A/C] likes?” For example, if the student selected that A liked food1, the teacher would prompt, “Do A and B like the same or different?” and then “Which food is the same as what A likes?” prior to the correct food item being selected; this pre-trial prompting was then provided for all subsequent trials with that relation for that stimulus set, as detailed in Figure 8.11 below.

Intervention Step Four: DRR Training with Pretrial Prompting

① Same food stimulus set used for first trial of correction procedure, then new food stimulus set selected by program for each subsequent trial.

② Same A/C stimulus highlighted by program for first trial of correction procedure, then new A/C stimulus highlighted (quasi-random selection) for subsequent trials.

③ Participant selects and drags a food stimulus next to highlighted animal.

④ B stimulus highlighted by program.

⑤ Pretrial prompting* provided by teacher, then participant selects a food and drags next to B stimulus.

⑥ Trial scored as correct/incorrect; e.g., correct response given relation B (dog) ≠ C (turkey) is to drag peas next to dog. Reinforcement provided for correct responses.

*⑤ Pretrial prompting:
 a) Prompt to tact relation (e.g., “Do the dog and the turkey like same or different?” “Different”).
 b) Prompt to identify food relation (e.g., “Which food is different from what the turkey likes?” “Peas”)

Figure 8.11. MET intervention step four: DRR training for relations on which errors had been made. DRR training continued with new food stimulus sets until 6 consecutive correct responses had been made.

The intervention phase continued until the participant completed three animal stimulus sets in which all responses were correct (and thus no pre-trial prompting was provided). Following the intervention phase, DRR testing was then conducted with the same procedures as in baseline, and generalization was tested using the written “story” on the whiteboard.

Results and Discussion

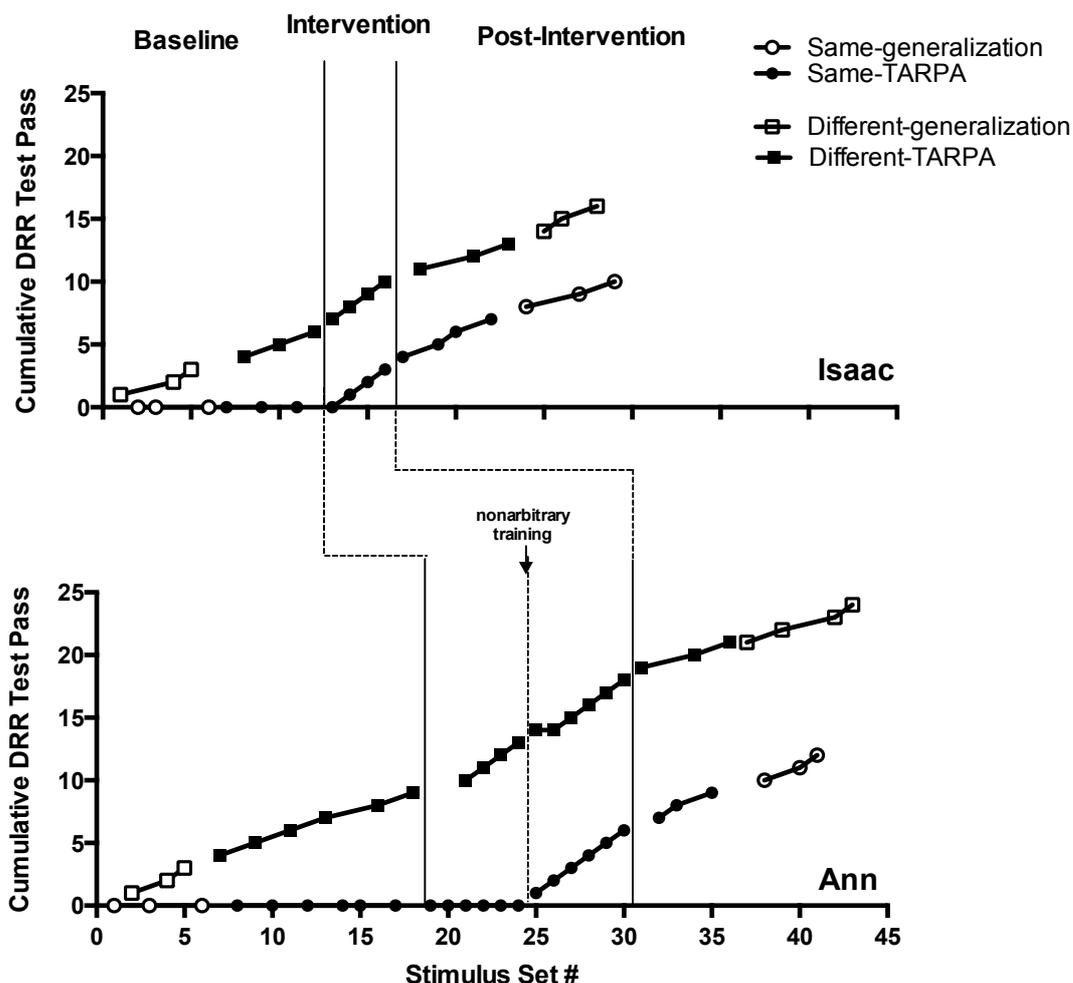
Results for both participants are shown in Figure 8.12, which displays the cumulative number of DRR trials correctly completed. Both participants readily passed conditional discrimination training, rarely making any errors. However, on DRR tests during the baseline phase, both showed a distinctive pattern of consistently selecting the “different” food from the one selected for the first animal highlighted, as had also been seen with participants in the previous studies. As a

result, their responding on DIFFERENT DRR tests was consistently scored as correct, while their responding on SAME DRR tests was consistently scored as incorrect. As with the earlier participants, even though their responding on DIFFERENT tests was 100% “correct”, the overarching pattern clearly indicated that responding was not under control of the contextual cues.

Both participants readily responded to relational tact trials once the intervention phase began, with almost no errors on any stimulus sets. However, as with Evan in the earlier study, simply training the relational tacts was insufficient for correct responding on DRR tests: both failed at least the first set of DRR tests following relational tact training.

Isaac quickly responded to the DRR training. In the first DRR training session with the first animal stimulus set (with teaching trials on 8 food stimulus sets), he made errors on the first trial of SAME, but then was able to correctly select the foods on the basis of both relations between the animals with pretrial prompting. He responded to all trials correctly in the following three training sets without any need for further teaching, and then was able to correctly respond to DRR tests alone in the post-intervention phase. He was also then able to respond accurately in the generalization test when the relations were presented in written form.

Ann was not as easily able to learn the relevant responses, and the difficulty of the task (even with pretrial prompting provided) initially affected her motivation to respond. For the first two animal stimulus sets in DRR training, several food stimulus sets were needed before she could respond correctly to SAME trials. Perhaps at least partly as a result of this, in both cases, she asked to be finished after completing the final trial correctly, and thus the session was terminated before any DIFFERENT trials could be presented. By the third animal stimulus set, she was able to respond to the teaching procedures correctly within the DRR training sessions (i.e., she responded correctly when prompted to pick the food that was the same or different). However, she did not respond consistently nor with the first trial correct on SAME for six consecutive stimulus sets.



incorrectly on several trials during the first animal stimulus set and thus required 19 teaching trials for that set. She then responded at 100% correct responding for two subsequent sets, and thereafter was returned to the arbitrary training.

During the first arbitrary game set following the non-arbitrary training, she responded correctly to the first SAME test, but later responded incorrectly and thus received further pretrial prompting. On the next set, she responded correctly to SAME but incorrectly to DIFFERENT, as well as incorrectly on later SAME trials, and thus required pretrial prompting on both trial types. Similarly, on the third animal set, she initially responded correctly but then made errors on subsequent food stimulus sets. Following this set, she responded correctly to all trials for both trial types for three sessions, and was then given post-intervention testing, which she passed. During the generalization testing, on the first test (DIFFERENT), she at first responded incorrectly, but then, unprompted, immediately changed her response (this trial was nonetheless scored as incorrect based on her first response). She subsequently responded correctly on three additional DIFFERENT tests as well on three SAME tests presented in random order.

Both of the participants were thus able to demonstrate DRR following the implementation of the training procedure that had been developed in Study 8.2, when they had not been able to do so prior to training, and to generalize this skill to a simple test of reading comprehension. While previous work (Dunne, et al., 2014) provided important preliminary demonstrations of the training of derived same/different relations in children with autism, this study extends that work by being the first controlled demonstration of the effectiveness of such training. Previous studies had suggested the potential of MET for same/different responding but had not set out to specifically study its effectiveness in an experimentally controlled manner. The additional implications of the current study will be discussed further below.

General Discussion

The work presented in this chapter furthers the research on early emergent repertoires of DRR in a number of ways. Study 8.3 represents the first controlled demonstration of the effectiveness of multiple exemplar training for the

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establishment of a repertoire of DRR in accordance with distinction with children with autism, as well as a demonstration of the generalization of this skill to an important academic domain (i.e., reading). This work also resulted in the development of a practical tool to assess and establish same/different relational responding using an ecologically valid context relevant to everyday conversational and academic skills.

One additional notable feature of all the current studies is that they used a test of derived relations involving the emergence of novel functions for the related stimuli. The emergence of novel functions for stimuli based on derived relations with other stimuli is referred to in RFT as *transformation of function*, and indeed, as noted in previous chapters, this phenomenon is seen as one of the defining properties of relational framing². To review, for instance, when stimuli are related in a frame of coordination (i.e. sameness), such that $A = B$ and $C = B$, any stimulus function that A has would be expected to transfer to stimulus C. For example, Rehfeldt and Root (2005) taught individuals to exchange a picture to mand for a reinforcer (i.e. established a manding function for pictures), and then taught conditional discriminations between the pictures (A) and vocal words (B), and between text cards (C) and the vocal words (B). Thus, the picture was related in a frame of coordination/sameness with the textual name of the item. Based on this relation, the exchange/mand function transferred from the picture to the text, such that the individuals in these studies were able to mand by exchanging a text card, even though such a mand had not been specifically taught, nor had the specific relation of $A=C$ been taught. That is, derived manding emerged. As noted in previous chapters, there have been many experimental demonstrations of such transformation of function in accordance not just with frames of coordination but also others, including

2. From an RFT perspective, in fact every derived relational response involves transformation of function; however, it is helpful from a pragmatic perspective to separate relational functions (such as the discriminative functions involved in demonstrations of mutual or combinatorial entailment) from non-relational stimulus functions (such as perceptual functions, other discriminative functions, respondent functions, and so on). See Hayes, Fox et al. (2001) and Barnes-Holmes, Hayes, Dymond & O'Hora (2001) for further explication of this distinction.

opposition, comparison, and hierarchy, and involving a variety of respondent and operant functions (for a review, see Dymond & Rehfeldt, 2000; also see, e.g., Barnes & Keenan, 1993; Dymond, Roche, Forsyth, Whelan & Rhoden, 2007; Gil, Luciano, Ruiz & Valdivia-Salas, 2012; Perez-Gonzalez, Alvarez, Calleja & Fernandez, 2015; Stewart et al., 2015).

Children with autism are often described as responding “rotely”—that is, in a way that suggests they do not truly “understand” what they are saying but are only repeating what they have been taught. As suggested in the introduction to this chapter, one sense of the use of this description might be that they have learned a variety of conditional discriminations, but the stimuli do not participate in a variety of relational frames and do not take on new, contextually controlled, functions as a result. Such was the case in the current studies, in which the pattern of responding seen with all participants during baseline suggests that they were not responding in accordance with the appropriate pattern of derived relations based on the relations taught, but rather only by selecting whichever food had not yet been selected. It is possible that they were simply showing exclusion at this point, and as discussed in Chapter 7, this is in fact likely an important prerequisite skill for DRR in frames of distinction. Since trained or derived exclusion was not specifically tested for, it is difficult to say with any certainty that the participants were responding on this basis. Regardless, simply being able to state that “A likes the same as B” or that “B and C like different food” did not allow them to make any other response that was in accordance with the specified relation. After appearing to come under appropriate contextual control for relational responding via the intervention, however, they were then able to respond correctly to the tests of DRR. That is, they seemed to be able to demonstrate contextually controlled transformation of function, in which the discriminative function for one stimulus (e.g., C likes candy) was transformed for the other (e.g. B likes chips), in accordance with the relation (e.g. difference). Further research is needed to explore this outcome more fully, but for these participants the MET intervention appeared to be successful in training them in this new repertoire of DRR.

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With regard to testing for transformation of function, it has been argued (e.g., Hayes, 1991; Dymond & Rehfeldt, 2000) that under certain circumstances, an effect that appears to be transformation of function (ToF) might actually be the result of direct associative processes (e.g., stimulus compounding) and thus might not be a demonstration of derivation. This could be the case when tests of ToF occur following tests of stimuli that have been previously paired, such as when ToF tests follow tests of equivalence. It could be argued that such an outcome might also have been expected in this study, given that the two types of training to establish the relations between stimuli (see Figure 8.10), both involved some level of pairing of the stimuli (i.e. AB or CB) that were later tested. Pairing of stimuli may have been particularly salient during the relational tact training, in which both stimuli were directly paired together to serve as the discriminative stimulus for the response of selecting SAME or DIFFERENT. An argument against this line of reasoning, however, is that stimuli in each of the relations (AB, CB) were equally paired during training, in which case one might expect that the function given to one stimulus would be the same for the other. That is, whether A or C was given a function, B would take on the same function due to the pairing. Thus, the pattern seen would not be one in which the function was transformed depending on the relation of same or different—instead, it would always be the same function. Stimulus compounding would thus not be a reasonable explanation of any demonstration of ToF in this case. Moreover, demonstration of ToF did *not* occur following this direct pairing of stimuli for these participants (nor, anecdotally, for other students with whom these procedures had been piloted): even following the relational tact training, both participants made errors during the subsequent DRR training trials. That is, the pairing of stimuli alone was insufficient for them to respond correctly on tests of ToF, and it was only following the MET intervention that the participants could demonstrate the derived responses. Future research should nonetheless examine ToF based on stimuli that have not been paired during initial training. For example, if students are trained in relations of $A=B$ and $C\neq B$, and then learn what food A likes, will they be able to derive what food C likes? If not, would the DRR training intervention facilitate such derivation?

A task that examined ToF based on stimuli that have not been previously paired would also necessarily extend this study to more systematically examine combinatorially entailed relations, as were assessed with Paul in Study 8.1. These could be examined both in combinations of same/different relations as in the current studies, as well as in difference relations alone. It is possible that the participants in Study 8.3 may have been able to demonstrate combinatorially entailed relations, since they were asked to respond to the ToF task under unreinforced conditions with respect to all three stimuli. However, A-C relations alone were not examined in that study. These relations were only tested following a response being made with respect to B; participants thus may have responded on the basis either of the relation with B or of the relation with the other stimulus. In order to examine combinatorial entailment in combined relations of same/different, one option is to add a fourth stimulus to the network, as was done in Study 8.1, such that $A=B$ and $C \neq B$, and $D=B$. This allows for testing to randomly alternate between combinatorially entailed relations of SAME ($A=D$) or DIFFERENT ($A \neq C$), in order to ensure participants do not just learn to always respond with the DIFFERENT stimulus. Alternatively, without adding a fourth stimulus, the testing relations could randomly alternate between coordination alone ($A=B=C$, therefore $A=C$), or coordination combined with distinction ($A=B \neq C$, therefore $A \neq C$).

Combinatorially entailed relations of distinction alone are difficult even for typically developing adults (see for example, Vitale, Barnes-Holmes, Y., Barnes-Holmes, D., & Campbell, 2008) because they involve an unspecified answer: if A is different from B, and C is different from B, it is impossible to know if A and C are different unless there are only two options to choose from (as in the current study). Moving into more complex, unconstrained choices is also thus necessary for future work on distinction relations and would likely be particularly applicable to individuals with more advanced language skills.

Future research is also needed to investigate the relative effectiveness of the two types of training employed in the intervention to initially establish the relations between the stimuli. First, participants were trained using a conditional discrimination training procedure that can be seen as similar to an intraverbal fill-in

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(B likes same as: A). The second procedure trained participants to tact the relation between pairs (B and C like: different). The relational tacting procedure was included based on the performances of the participants in earlier case studies, who were not always able to demonstrate relational tacting following the conditional discrimination training. This deficit made it difficult to determine whether the lack of responding to derivation tests was due to a true lack of this repertoire, or to insufficient learning of the baseline relations. Other work (Quah, 2013) has also indicated the potential for relational tact training to facilitate derived relational responding, and it was anticipated that at minimum the relational tact training would provide additional support for any derivation skills in the participants' repertoire. Future research might explore whether either procedure is more or less effective or efficient with respect to establishing the initial relations, and with respect to facilitating DRR.

Finally, in addition to using a meaningful context to test for transformation of function, the current work represents the first studies with children with autism to train same/different relational responding and also explicitly test for generalization to an academically-relevant task: a simple test of reading comprehension. The results thus also highlight the complex relation between generative language skills and reading comprehension. As Newsome et al. (2014) have noted, relating concepts in terms of sameness and distinction is critical for reading comprehension. They worked with five children aged 9-12 who were identified as struggling with reading comprehension, and provided intervention to strengthen participants' abilities to discriminate hierarchical relations on the basis of same/different (e.g., "How is rice different from/same as watermelon?"). This intervention not only improved fluency and novelty of responding, but also improved measures of reading comprehension, particularly for participants with more advanced pre-existing repertoires. I would agree with their conclusions that RFT provides a useful way to examine language and reading comprehension, and can provide a framework for the development of effective teaching programs addressing comprehension deficits. In the current study it was not until the pattern of derived relational responding was specifically trained that the participants could respond to the text-based relations in a "meaningful" way.

However, only one context was examined, with a limited set of relations and a very simple generalization test. Additional work could provide training in same/different relations in a variety of contexts and monitor additional measures of reading comprehension as well as language development over time. Future research might also more specifically examine the relationship between reading comprehension and demonstration of DRR in accordance with the relational patterns required by the text at varying levels of complexity and types of frames.

Newsome et al. further noted that the two participants in their study with more significant language impairments did not demonstrate results as robust as those participants who were typically developing, and suggested that training in earlier forms of relational responding, including non-arbitrary relations, may have been helpful. These suggestions seem very reasonable and in line with the results of the current studies as well. For learners who do not yet have a robust non-arbitrary repertoire (as may have been the case for Ann in Study 8.3), this deficit is also likely to impact their arbitrary relational responding repertoire. Within the framework of combined same/different relations, it may be beneficial to strengthen the repertoire not only through generalization training with other contexts, but also through training that focuses on flexibility of non-arbitrary responding (i.e. by establishing additional contextual control). As an example, in the current study, the animals “liked” certain foods, and the non-arbitrary training focused on them identifying the relations based on the foods that were shown next to each animal. An extension of this could include also showing what toys they (animals, or perhaps a bit more logically, popular characters) liked to play with, houses they lived in, or clothing they liked to wear, in a larger grid of characters and associated stimuli. With this extension, the characters could be in varied relations depending on which function is being referenced—Barbie and Skipper might like the same food, but different toys. More important “real” content could of course also be taught in this way—such as where different animals actually live (e.g. farm or forest or desert), whether they have fur or feathers, how many legs they have, and so on. At the non-arbitrary level, such training should be relatively straightforward, has the potential to increase flexibility of responding more generally, and may have the potential to lead to more

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rapid acquisition of arbitrary relational responding skills as well. All these are empirical questions awaiting further study, and are critical to understanding how more advanced language repertoires such as hierarchical categorization (as studied by Newsome et al., and as will be examined further in the next chapter) might be most effectively taught .

In summary, the results of these studies should be viewed as preliminary, particularly in that the systematic evaluation of the MET intervention involved only two participants. Replication and extension of the procedures with additional participants, including those at different skill levels and ages, is necessary. Moreover, this study examined only one simple context—additional contexts that would also be relevant to conversational and academic skills should be examined, as well as generalization to novel contexts once responding in one context has been established. Nonetheless, while there is much work to be done exploring the many variables related to establishing same/different responding, the results here have extended the research on early emergent DRR and also have implications for curriculum development for children with autism. Rehfeldt (2010) has noted that in order for behavior analysts to develop a meaningful and broadly applicable technology of derived stimulus relations, among other things we must move beyond relations of sameness, examine generalization to topographical skills, and examine the role of derived relations to advanced reading (and other academic skills). This study represents an important, if very beginning, step in these respects. By viewing the critical skill of same/different responding through the lens of derived relational responding, we may be better equipped to develop new tools for analyzing and remediating rote responding. With such tools, we may be able to much more effectively teach students to “speak with meaning” and “listen with understanding” (Hayes, Barnes-Holmes, & Roche, p 3).

Chapter 9:
Training Class Inclusion

Portions of the material in this chapter are in preparation for journal submission as:

Ming, S., Mulhern, T., Stewart, I., & Moran, L. (in preparation). Testing and Training Class Inclusion in Typically Developing Young Children and Individuals with Autism.

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The final studies in the current line of research involved the training of a task related to categorization and hierarchical relational framing. As discussed in Chapter 7, same/different relational responding can be seen as foundational to many other frames, including hierarchy. However, although some work has been done examining the effect of strengthening the same/different and hierarchical framing skills of both typically developing children and children with developmental disabilities, as discussed in the previous chapters (e.g., K.B. Newsome, Berens, Ghezzi, Aninao, & W.B. Newsome, 2014), there is currently no work with children with autism with respect to training early emergent DRR in patterns of hierarchy. Hence, these final studies examined skills that are related to hierarchy and categorization, and which might reasonably follow on from training in distinction from the perspective of a curricular sequence.

Categorization, defined as a “pattern of systematic differential responding to classes of non-identical, though potentially discriminable, stimuli” (Zentall, Galizio & Critchfield, 2002, p.238), has been described as fundamental to cognition and concept learning (e.g., Lakoff, 1987). Behavior analysts have done important work assessing and training categorization relevant skills in children with ASD. For example, one recent research stream has used a derived equivalence paradigm to do so (Miguel, Petursdottir & Carr, 2005; Miguel, Petursdottir, Carr & Michael, 2008; Petursdottir, Carr, Lechago & Almason, 2008; Miguel & Kobari-Wright, 2013; Kobari-Wright & Miguel, 2014). In these studies, which have involved both typically developing preschoolers as well as children with autism, participants have typically first been trained to tact and/or receptively identify a number of different though categorically related stimuli (e.g., wrenches, hammers and drills) both individually as well as by using a common category name (such as “tools”). Subsequently the children have been tested for emergent categorization-type skills, such as being able to name members of the category (e.g., by responding correctly to the question “Tell me some tools”) or correctly naming the category when given

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names of members (e.g., responding “tools” when told “wrench, hammer and drill”) without additional training.

While this work is important, it arguably focuses on categorization at a relatively basic level. For example, one important feature of more advanced categorization is that categories can be hierarchically related. For instance, a “poodle” is a member of the category “dog”, while “dog” is a member of the category “animal”. However, not all animals are poodles. In order to fully understand categories, it is important that children learn to respond appropriately in accordance with this feature.

One test of categorization commonly used in mainstream psychological testing that assesses correct responding in accordance with hierarchical classes is the so-called *class inclusion* task. In a typical example of such a task, a child is first shown an array of stimuli in a particular class that includes two different subclasses with a greater quantity of one subclass than the other. They are then asked whether there are more members of the more populous subclass or more members of the class. For example, the child might be shown an array of red and blue flowers with more red flowers than blue flowers in the array and asked “Are there more red flowers or are there more flowers?” The aim of the task is to ascertain if children can respond to a stimulus as simultaneously belonging both to a class as well as to a subclass contained in it.

Piaget (e.g., 1952) used the class inclusion task as a key measure of whether typically developing children had reached the so called “concrete operational” stage of development, which he claimed they typically reached by age seven or eight. Classification and sorting and grouping of sets and subsets of items is also considered an important competency for older preschoolers and kindergarten-age students to develop as a foundation for important mathematics abilities such as set logic and algebraic grouping (California Department of Education, 2008).

Despite the Piagetian assumption that class inclusion (in common with other cognitive skills) is based on maturation, a number of researchers have attempted to train class inclusion skills in young typically developing children (Kohnstam, 1963; Ahr & Youniss, 1970; Brainerd, 1974; Schwebel & Schwebel, 1974; Siegel,

McCabe, Brand & Matthews, 1978; Judd & Mervis, 1979; McCabe & Siegel, 1987; Agnoli, 1991; Greene, 1991; Quayle & Pasnak, 1997; Siegler & Svetina, 2006). These studies have used various combinations of quantification (i.e., counting the items in the sets), feedback and reinforcement to teach children ranging from about 4 to 7 years old to respond to class inclusion tests. Despite some success, however, when generalization and maintenance have been tested, results have been less promising (e.g., McCabe & Siegel, 1987). Furthermore, and perhaps more importantly from the current perspective, there has as yet been no such work conducted with children with ASD or other forms of developmental delay.

A behavior analytic approach to conceptualizing and subsequently training class inclusion as a core aspect of hierarchical categorization might yield training protocols with greater success in terms of establishing a relevant generalized repertoire in young children both with and without developmental delay. Such an approach was adopted in the current studies. As with all the work in the current line of research, the studies in this chapter are based on Relational Frame Theory (RFT; Hayes, Barnes-Holmes & Roche, 2001; see also Dymond & Roche, 2013), which explains complex behavior such as hierarchical categorization in terms of learned contextually controlled relational responding. From an RFT point of view, this contextual control is strengthened over time through contacting multiple exemplars of the relational pattern in question. In addition, relational patterns are typically learned first with respect to non-arbitrary properties of stimuli (e.g., learning to choose a greater quantity of items when asked to pick “more” and a lesser quantity when asked to choose “less”) and through multiple exemplar training, are subsequently “abstracted” so that eventually events can be related solely on the basis of the cues alone and thus in the absence of any obvious physical relationships (e.g., deriving that person X has “more” money than person Y when told that the latter has “less” than the former, despite not seeing physical quantities of money), which is referred to as arbitrarily applicable relational responding or relational framing.

From an RFT point of view, a complete understanding of categorization requires a relatively advanced repertoire that includes what is referred to as hierarchical relational framing (see, for example, Slattery & Stewart, 2014).

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However, fully abstract hierarchical relational framing has its roots in simpler relational repertoires such as class inclusion. Although class inclusion is arguably a marker of more advanced language skills than responding on the basis of equivalence relations, it is still a type of generalized non-arbitrary relational responding, and thus less complex than fully arbitrary hierarchical relational responding. Learning a class inclusion repertoire is likely to be critically important for learning more advanced categorization abilities, and furthermore, RFT would suggest that class inclusion itself should be something that can be learned through multiple exemplar training at the non-arbitrary relational level. With respect to the exploration in this thesis of the emergence of early repertoires of DRR that provide a foundation for more advanced generative language, class inclusion seems like a reasonable skill to examine. While it likely emerges later in a child's learning history than coordination and distinction, all of these repertoires form important foundations for many more complex arbitrary relational responding repertoires, including categorization.

Strengthening the precursors to categorization in young children with ASD is likely to improve their everyday functioning as well as accelerating their acquisition of intellectual skills more generally. As suggested, class inclusion is a relatively important feature of this repertoire. Heretofore, however, no investigation or remediation of class inclusion had been undertaken in this population. RFT provides a relatively clear conceptualization of class inclusion in terms of relational responding and would suggest that multiple exemplar training in a non-arbitrary relational context can provide a potentially powerful means by which to establish and strengthen this repertoire. The aim of the current research, therefore, was to assess and train class inclusion using an RFT inspired training protocol.

Study 9.1: Case study of MET for class inclusion

The first study was conducted based on previous (unpublished) work with typically developing children (Mulhern & Stewart, 2014). The main aim of the protocol developed by the latter was to highlight the "containment" relationship between a category and its members. In the current case study, this protocol, which

will be described in detail in the procedure section below, was tested and then modified.

Methods

Participant and Setting. One child with autism participated in this study, Paul, who had previously participated in Studies 5.1 (Single case investigations of context) and 7.1 (Case study in the assessment of distinction relations). Paul was 10 years 6 months old at the beginning of this study, and was assessed with an age-equivalency score of 5-3 on the Peabody Picture Vocabulary Test (PPVT).

Materials. Materials consisted of 5.5cm square colored flash cards of items from four different categories: animals, fruit, clothing and vehicles. Each category included six different stimulus types (e.g., for animals, examples included dog, cat, horse, cow, pig and sheep). In addition, for the first set of interventions, a standard US letter sized laminated sheet was used, on which there was one large circle and two smaller circles inside the larger circle (see Figure 9.1). Whiteboard markers were used to label these with the category name and the stimulus types. For the second set of interventions, a set of clear plastic containers was used. There were two small containers for the stimulus cards, on which the names of the stimuli were written (e.g., “horses” and “pigs”) and these nested inside a larger container on which the category name (e.g., “animals”) was written. Whiteboard markers were used to label these containers (see Figure 9.2).

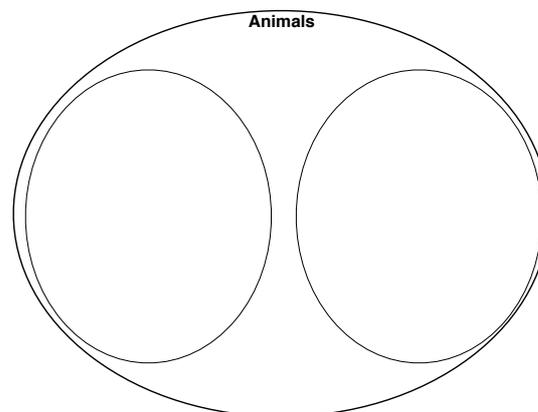


Figure 9.1. Intervention 1 presentation format: Two-dimensional nested circles.

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Figure 9.2. Intervention 2 presentation format: Nested plastic boxes.

Two sets of cue cards were used to randomize the presentation of trials in terms of stimuli used and trial types. One set consisted of variations in stimulus type and respective number (e.g., “2 cows 5 dogs”, “3 shirts 5 socks”), with cards representing all possible variations of more or less of each stimulus type within a category (e.g., every animal was represented in a pair with every other animal in a relation of more and a relation of less, so one card would have more cows than dogs, another more dogs than cows, and so on). The second set consisted of trial type prompts for the experimenter, with variations in the phrasing of class inclusion questions, with eight variations of category and stimulus type order to balance questions between asking about the stimulus type with a larger vs smaller amount, and asking “more” vs “less” questions. Questions were also counterbalanced to control for potential echoic control over responses (that is, to ensure that questions could not consistently be answered correctly simply by repeating the final word). Table 9.1 shows the eight class inclusion question types. Trial type cards also included a variety of interspersal questions, which consisted of mastered questions either requiring a tact or receptive identification of the item, the category, the quantity of items, or some other mastered question about a stimulus’ properties (e.g.,

“Which one says moo?”, “How many cows are there?”). Interspersal questions were included to maintain student motivation by providing lower response effort tasks, as well as to provide a check on other factors that could influence responding; that is, if interspersal questions were answered incorrectly, one could suspect motivation or other factors such as attention as an unwanted influence on responding to class inclusion trials. Trials were presented randomly, with a ratio of one interspersal trial to one class inclusion trial.

More [category] or more [stimulus1]	More [category] or more [stimulus2]
Less [category] or less [stimulus1]	Less [category] or less [stimulus2]
More [stimulus1] or more [category]?	More [stimulus2] or more [category]
Less [stimulus1] or less [category]?	Less [stimulus2] or less [category]?

Table 9.1. Class inclusion questions: Eight variations of more vs less, counterbalanced for order of stimulus type and category. [stimulus1] refers to the specific stimuli with the smaller amount (e.g., 2 cows); [stimulus2] refers to the specific stimuli with the larger amount (e.g., 5 dogs).

Screening. Prior to beginning participation in the study, the participant was screened using tabletop discrete trial procedures to ensure he was able to (a) tact all stimuli used; (b) respond correctly to yes/no stimulus identification questions (e.g., “Is this a cat?”); (c) tact the category of all stimuli used (e.g., “What category does this [picture of a cat] belong to?” “animals”); (d) tact quantities of stimuli from 1 to 10; and (e) respond correctly to questions of quantitative comparison between stimulus sets (e.g., “Are there more cats or more horses?”).

Baseline. At the start of each baseline session, each set of cue cards (trial type and stimulus selection) was first shuffled. The participant was then asked to select a stimulus card, and the administrator laid out the two stimulus sets on the table as described by the stimulus card, such as one pile of picture cards consisting of 3 cats, and another consisting of 5 horses. The experimenter then selected a trial type card as described above and presented the relevant trial (class inclusion question or interspersal question). Once the participant responded, stimulus sets were removed, a new stimulus card and new trial type card were selected, and the next trial began.

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During baseline, all four categories of stimuli (animals, fruit, clothing and vehicles) were used.

During baseline, nonspecific praise was provided for all trials (e.g., “You’re working really hard!”, “I like how you’re paying attention!”), and reinforcement for participation was provided on the schedule identified by the participant’s teacher as appropriate to a teaching session. No feedback or reinforcement contingent on correct responding was provided. Only responses to class inclusion questions were recorded. Twenty class inclusion trials were presented, in a ratio of one interspersal question to one class inclusion trial for a total of 40 trials per session; sessions lasted approximately 20-30 minutes and were conducted two to three times per week.

Intervention 1. The first intervention consisted of multiple exemplar training on the class inclusion relation using a two dimensional presentation showing the relation between stimuli (see Appendix D for full scripts for all tabletop procedures). Only animals were used as stimuli during intervention, but otherwise the trial types and randomization of trials as described for baseline remained the same. During intervention, a presentation sheet (as shown in Figure 9.1) was placed on the table and was used for all trials. Above the larger circle was the name of the larger category, that is, “Animals”. Once the participant had made the stimulus card selection, the experimenter placed the relevant cards in the circles, and wrote down the name of the animals under each of the circles (e.g., one circle might contain cats, and the other might contain horses). The experimenter then selected a trial type card and presented the trial.

During intervention, correct responses for all trial types were followed by specific praise and feedback (e.g., “That’s right, these are cats!”, “You got it, there are more animals than cats!”). Incorrect responses to class inclusion questions were followed by a specific statement of corrective feedback, depending on whether the question required the participant to answer a “more” or a “less” question, as follows. For “more” questions, while pointing to the relevant circles the administrator stated that, “a [animal1] is a type of animal, and [animal2] is a type of animal” (e.g., “a cat is an animal and a horse is an animal”), and then stated, “since these are all animals, there are more animals than [animal1/2].” For “less” questions, the administrator

stated that, “a [animal1/2] is a type of animal, but not all the animals are [animal1/2]” (e.g., “a cat is an animal but not all the animals are cats”), and “since these are not all [animal 1/2], there are less [animal1/2] than animals.” Following the corrective feedback, the administrator repeated the original trial type question with that same stimulus set, and correct responding was reinforced. A new stimulus set was then selected, and the same trial type was repeated (e.g., if the error was with respect to the trial type question “Which has more, [animal 1] or [category]?”, then that same trial type was repeated with the new stimulus set). Corrective feedback and subsequent re-presentation of the trial type with a new stimulus set continued until the participant could respond correctly on the first trial with a new stimulus set. At that point, a new trial type card was selected.

Intervention sessions continued until 20 class inclusion trials had been completed (or earlier if necessary, as based on participant motivation or behavior), and typically lasted 30-40 minutes. Two to three sessions were conducted per week. Intervention was planned to continue until the participant reached a criterion of 90% across two consecutive sessions or 100% within a session.

Intervention 2. The second intervention followed the same procedures as the first, but added in specific instructions along with gestures to further increase the salience of the relation. Both when setting out the stimulus cards as well as during correction following errors, the participant was prompted to attend to the “big” category circle and the “small” stimulus type circles.

Intervention 3. The third intervention replaced the paper sheet with plastic boxes: one large plastic box, which then contained two smaller plastic boxes (as shown in Figure 9.2). This intervention was designed to increase the salience of the containment relation. During the correction procedure, this allowed for physically showing both the category box as containing all the items, as well as a single box lifted out of the larger box containing only the specific stimulus type.

Intervention 4. The fourth intervention added in a pretrial prompting requirement to pick up the category box (e.g., “show me the animal box”) and also pick up the stimulus box (e.g., “show me the pig box”), with correction provided if errors were made. In addition, the number of trials presented was altered such that

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the session terminated after each class inclusion type question had been answered correctly once, rather than after twenty total trials. This allowed for a potential reduction in session length as the participant gained mastery, and also ensured that all trial types were presented at least once.

Inter-observer agreement. Inter-observer agreement was collected by a second observer (the participant's teacher) for 20% of sessions, with 100% agreement in all sessions.

Results and Discussion

Paul's results are shown in Figure 9.3, which displays the percentage correct for the first trial of each class inclusion type. During baseline, Paul's performance displayed a pattern in which for most sessions most class inclusion questions about the larger stimulus type were answered incorrectly, while questions about the smaller type were generally answered correctly (e.g., if there were 6 oranges and 3 lemons, any class inclusion questions about oranges would be incorrect, while questions about lemons would be correct). Thus while the percentage correct varied within levels that suggested chance responding, his responding was not "chance" but suggestive of specific and consistent stimulus control.

During the first intervention, Paul's responding appeared to improve on the second training session, and the pattern of responding was different than seen in baseline. While his performance declined back to baseline levels after an initial increase, the pattern of responding was more indicative of the earlier stimulus control being disrupted. He no longer responded consistently. However, he also did not respond with a pattern that indicated appropriate stimulus control was being established. Changes to the phrasing of the pretrial stimulus set up and correction procedure in intervention two did not result in a more consistent and appropriate pattern of responding. At this point, the change to the use of boxes was implemented.

After the first session of the third intervention phase, in which plastic boxes were used, it became apparent that Paul could not correctly identify the category box. When asked to identify the animal box after identifying one of the stimulus boxes (e.g. the pig box), he picked up the other stimulus box (e.g. the horse box). At

this point, the additional pre-trial prompting and correction procedures involving the selection of the boxes was added to the protocol. Although this initially appeared to result in improvement, his performance again declined after four sessions. Motivation to participate in the instructional sessions was clearly declining, with Paul making many requests for breaks and to stop the sessions. It was difficult to determine whether the change in performance was due to motivation or some spurious source of stimulus control following the many changes to the intervention protocol. At this point it was decided to terminate the study, and instead allow Paul's teacher to incorporate the strategies into his regular math activities.

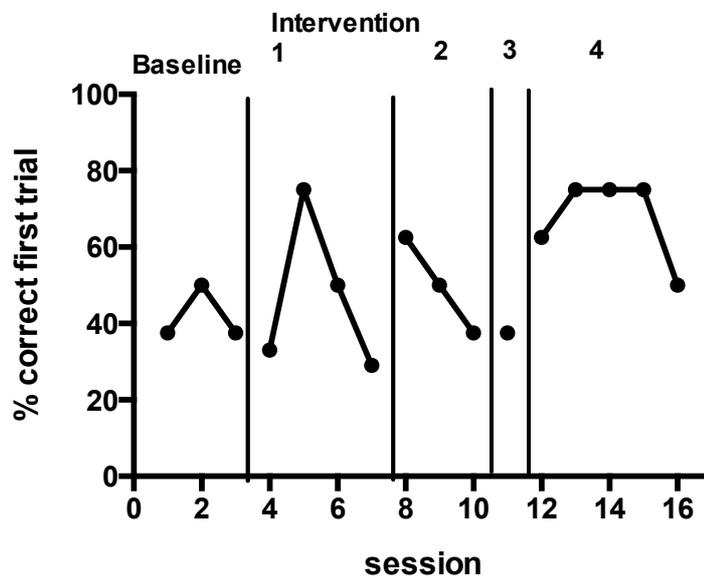


Figure 9.3. Results for Paul: Percentage correct on first trial for each of the eight class inclusion questions. Chance responding would be indicated by 50% correct.

Study 9.2: Training class inclusion with typically developing preschoolers¹

Following the initial case study, a nonconcurrent multiple baseline study was carried out to test the effectiveness of the final protocol developed previously.

1. This study was conducted in collaboration with Teresa Mulhern, ABA PhD Candidate at NUI Galway.

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Although this protocol had not yielded clear results, it was felt that it showed promise and that with the streamlined procedures other students may respond more quickly. Thus, a nonconcurrent multiple baseline study was conducted with three typically developing preschoolers to further pilot test the protocol prior to the final study, which then tested the protocol with three children with autism.

Methods

Participants and Setting. Three typically developing children participated in the study; all were enrolled in a small private half-day preschool program in rural Ireland. Participant T1 was age 3 years 6 months, participant T2 was age 4 years 1 month, and participant T3 was age 3 years 5 months.

Experimental Design. A nonconcurrent multiple baseline design was used, with participants pre-assigned to one of three baseline lengths (3, 5 or 7 sessions), as recommended by Watson and Workman (1981). Pilot research (also with typically developing children; Mulhern & Stewart, 2014) had indicated that 3 baseline sessions was likely to be sufficient to establish a stable trend, and that progress was likely to be shown quickly following intervention, both of which are important in the context of a nonconcurrent multiple baseline design (Christ, 2007).

Materials. As in Study 9.1, colored flash cards of items from four different categories (animals, fruit, clothing and vehicles) were used, each including multiple examples of six different stimulus types (e.g., for animals, examples included dog, cat, horse, cow, pig and sheep). During training, a set of clear plastic containers was used as in Study 9.1 in the third and fourth intervention phases (see Figure 9.2). Two sets of cue cards were used to randomize the presentation of trials in terms of stimuli used and trial types as described for Study 9.1. Trials were presented randomly in a ratio of one interspersal trial to one class inclusion trial.

Procedure. Screening and baseline sessions followed the same procedures as described above for Study 9.1. A session was terminated after all eight types of class inclusion questions had been asked. As class inclusion and interspersal questions were presented in a ratio of 1:1, there were 16 trials per session. Baseline sessions typically lasted approximately 10 minutes, and were conducted 2-3 times per week.

Intervention. For the intervention, multiple exemplar training using the class inclusion task involving nested boxes was employed as described in Study 9.1. The use of the nested boxes was to ensure the saliency of the relation of “containment” of the smaller stimuli within the larger category. Only the “animals” stimulus set was used for intervention, but otherwise the trial types, randomization of trials, and quantity of trials as described for baseline remained the same. Intervention consisted of two phases: first, a phase that included a number of pre-trial requirements designed to highlight the salience of the boxes, as described below (designated the errorless phase), and second, a phase that faded these pre-trial requirements (designated phase 2). (See Appendix D for full scripts for all procedures.)

Errorless Phase. During the errorless phase, sessions began by describing the larger box as being for the category and having the student identify the category (animals) and write the name on the box. Prior to each trial, the student wrote the names of the animals selected for the trial on each of the two smaller boxes, was instructed that the stimuli were all animals (e.g., “cats and horses are both animals”) and that they belonged to the animal category and went inside the animal category box, and then the student placed the two smaller boxes inside the larger box. The experimenter selected the trial type, and then directed the student to select the stimulus type for the trial (e.g., “Show me the horse box”) and select the category box (i.e., “Show me the animal category box”). If the student made an error in selecting the category box, the instructor corrected the response by demonstrating the correct selection, and then provided another opportunity to answer the question independently. Once both boxes had been selected correctly, the experimenter presented the trial, while lifting up each of the boxes as the instruction was presented.

Correct responses for all trial types were followed by specific praise and feedback (e.g., “That’s right, these are cats!”, “You got it, there are more animals than cats!”), while lifting up the relevant boxes. Incorrect responses to class inclusion questions were followed by repeating the requirement to select the stimulus type box and the category box, and then a specific statement of corrective feedback. During corrective feedback, the experimenter picked up the relevant boxes and stated

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(as relevant to the specific question asked) that the stimulus types (e.g. horses and pigs) were “types of animals, so they all go inside the big animal category box,” and that the stimulus types “all belong to the animal category, but only these are [stimulus type, e.g., horses], so there are more [or less] [stimulus type] in the [stimulus type] box than there are animals in the animal category box.” Following the corrective feedback, the experimenter repeated the original trial type question with that same stimulus set, and correct responding was reinforced. A new stimulus set was then selected, and the same trial type was repeated (e.g., if the error was with respect to the trial type question “Which has more, [animal 1] or [category]?”, then that same trial type was repeated with the new stimulus set). Corrective feedback and subsequent re-presentation of the trial type with a new stimulus set continued until the participant could respond correctly on the first trial with a new stimulus set. At that point, a new trial type card was selected.

Phase 2. During the next phase of intervention, the pre-trial requirement to select each of the relevant boxes was eliminated, and the verbal corrective feedback statements were reduced to stating, while picking up the boxes, that “they all belong to the animal category, but only these are [stimulus type, e.g., horses], so there are more [or less] [stimulus type] in the [stimulus type] box than there are animals in the animal category box.”

Intervention sessions in each phase continued until a correct response on each of the 8 class inclusion trials had been emitted, and typically lasted approximately 30-45 minutes. Two to three sessions were conducted per week. Intervention in each phase continued until participants responded correctly to the first trial presentation of each trial type.

Post-Intervention Probes. Once participants had reached criteria for the final intervention phase, generalization was assessed, using the same trial presentation format and procedures as in baseline. During the first probe, only animals were used to assess for maintenance of the skill in the absence of the visual support of the nested boxes, and then generalization to novel category types was tested, with all four category types again used as in baseline sessions. Maintenance was tested one

month following the final generalization probe, with one test of all category types, using baseline procedures.

Procedural fidelity and inter-observer agreement. Procedural fidelity checks (see Appendix C) and inter-observer agreement (IOA) was determined for all session types, including baseline, intervention, generalization and maintenance sessions, by a trained research assistant. Procedural fidelity ranged from 97.5% to 100% (mean of 98.6%). IOA ranged from 87.5 – 100% (mean of 99%).

Results and Discussion

Results for participants T1, T2, and T3 are shown in Figure 9.4. All participants showed performances at or below chance levels during baseline class inclusion tests. All participants also showed immediate improvements in performance upon initiation of the intervention, and met criterion for the errorless phase in two to four sessions. Participants T1 and T3 performed at 100% correct in the first session of intervention phase 2, while T2 required two sessions of phase 2 to meet criterion. All participants were subsequently able to perform at 100% correct responding during the post-intervention probe for the trained and for the untrained categories, and responded at 100% correct during the one-month maintenance test.

This study represented a successful demonstration of the effectiveness of the RFT-based class inclusion protocol, and further contributed to the existing literature on class inclusion by including a demonstration of both generalization and maintenance (for which there has been a lack of consistent evidence in previous research). Having tested the protocol with typically developing preschoolers, the next study then investigated the effectiveness of the protocol with individuals with autism.

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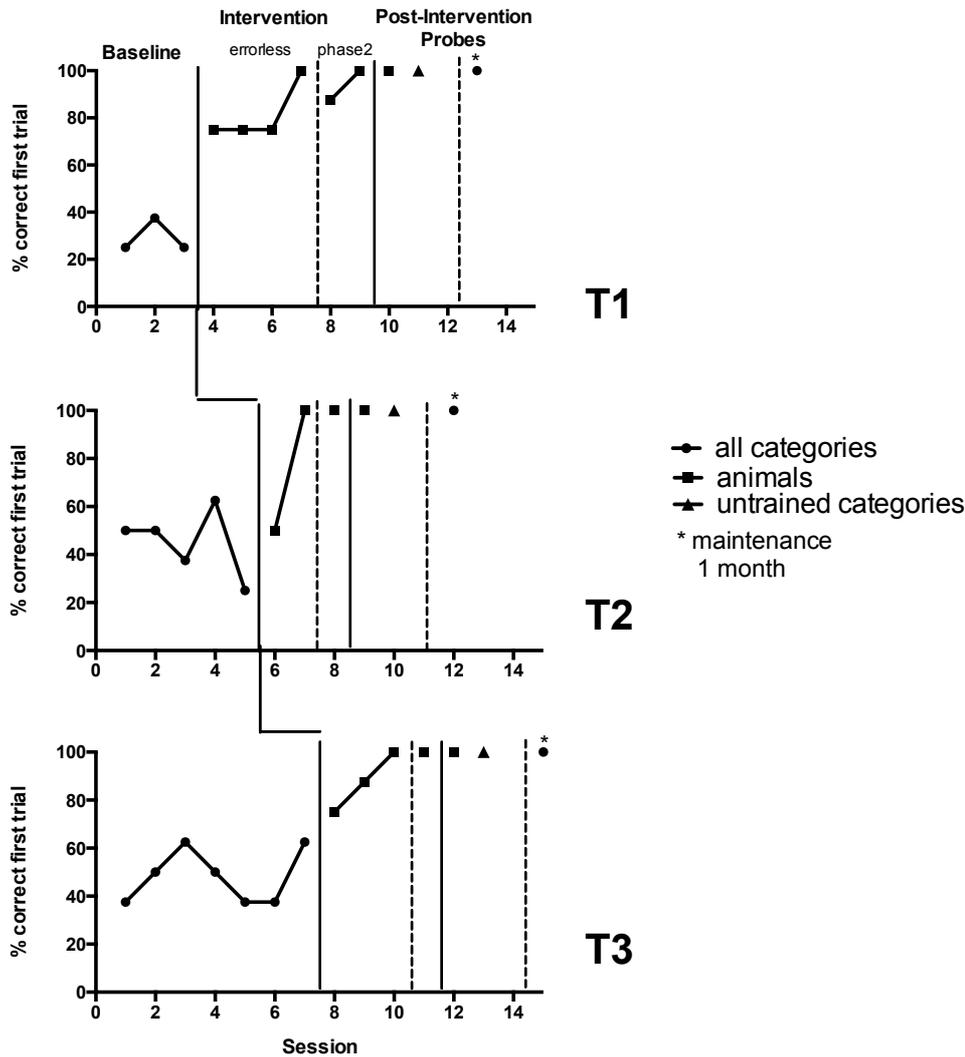


Figure 9.4. Results for first trial for each of the eight class inclusion questions for typically developing preschoolers, participants T1, T2, and T3. Chance responding would be indicated by 50% correct.

Study 9.3: Training class inclusion with individuals with autism

The final study investigated the class inclusion training protocol using a nonconcurrent multiple baseline design as in Study 9.2, again with participants pre-assigned to baseline lengths of 3, 5, or 7 sessions. The use of a nonconcurrent, rather than concurrent design, was necessary due to practical considerations in identifying participants at the appropriate skill level (determined by prescreening) and the fact

that the three participants were ultimately located in three different geographic locations. As noted previously with respect to the experiments on coordination in this thesis, there were several factors seen in pilot work that were felt to limit the potential for history to constitute a significant threat to internal validity (a concern often raised with respect to the nonconcurrent multiple baseline design). Most importantly, changes in the dependent variable following the introduction of the independent variable had been very rapid, while baseline responding had been stable. In addition, as in previous experiments, participants were pre-assigned randomly to different baseline lengths, as recommended by Watson & Workman (1981) and Christ (2007).

Methods

Participants and Setting. Three individuals with autism participated. Participant A1, age 8 years 1 month, had an age-equivalency score on the PPVT of 7-2. Participant A2, age 19 years 1 month, had an age-equivalency score on the PPVT of 7-11. Participant A3, age 9 years 7 months, had an age-equivalency score on the PPVT of 6-5. All participants were enrolled in specialized schools that provided individualized and small group instruction for children with autism; participant A1 was at such a school in Bangalore, India, participant A2 was located in Phoenix, USA, and participant A3 was located in Baltimore, USA. Sessions were conducted in a separate room at the school in which each participant was enrolled; sessions were conducted by teachers and behavior analysts at the schools where the students were enrolled, as well as by the author.

Procedures. All baseline and intervention procedures were conducted using the same protocols as described above for Study 8.2. In a slight modification from the previous protocol, maintenance tests for the participants in the current study consisted of two tests: one of the trained category (animals) and one of the untrained categories. In this way, any failure to maintain the trained skill could be separated from a failure to maintain the generalized skill. Maintenance was tested for the participants with timing varied based on participant and experimenter availability.

Training Class Inclusion

For participant A2, maintenance was first tested after 8 weeks. Participants A1 and A3 were tested for maintenance after 6 weeks.

Procedural fidelity and inter-observer agreement. Sessions were observed in person or via video for procedural fidelity (see Appendix C) for approximately 20% of testing sessions for each of the participants, with results ranging from 87.5% to 100% fidelity (average 97%). Inter-observer agreement was collected by a second observer for 20% of sessions for all participants, with 100% agreement in all sessions.

Results and Discussion

Results for participants A1, A2, and A3 are shown in Figure 9.5. During baseline, participant A1 showed responding at chance levels. Participants A2 and A3 showed a distinctive pattern in which for most sessions all class inclusion questions about the larger stimulus type were answered incorrectly, while questions about the smaller type were answered correctly (e.g., if there were 6 oranges and 3 lemons, any class inclusion questions about oranges would be incorrect, while questions about lemons would be correct), thus giving a relatively consistent score of 50% correct responding with little variation. Since participant A3 had been performing quite consistently at 50% for five of the first six baseline sessions and then increased to 62.5% in the seventh session, an eighth baseline session was conducted to ensure an upward trend had not begun; in this session he again performed at 50% correct. Following baseline, participant A1 reached criterion for the first (errorless) phase of intervention after five sessions. Due to experimenter error, he was tested in a sixth session with the errorless phase of intervention, in which he also responded at 100% correct. He then immediately responded at 100% correct in the first session of phase 2 of intervention, and in all post-intervention probes for both trained and untrained categories. A maintenance test was provided six weeks following the final post-intervention probe, and he responded at 100% correct for both the trained and untrained categories.

Participant A2 made an error on the first trial presented during the first session of the errorless phase of intervention, and then responded correctly to all

subsequent trials in that session, and met criterion for the errorless phase in the second session. Once phase 2 was initiated, he immediately responded correctly to all trials in the first session. Similarly in post-intervention probes he responded correctly to all trials on the trained category, and demonstrated generalization to the untrained categories with 100% correct responding. Due to vacation breaks, illness, and staff availability, participant A2 was not tested for maintenance until 8 weeks following the post-intervention probes. At that time, his performance on the trained category had returned to baseline levels. He was given one session of training using the phase 2 protocol, and immediately demonstrated 100% correct responding during that session. Subsequent post-intervention probes were successful for both the trained and generalization categories, tested immediately following training as well as in a second session two days later. A maintenance test was given after two weeks, in which one error was made with the trained category but no errors were made with the untrained categories; a maintenance test six weeks after that showed 100% correct responding for both trained and untrained categories.

Participant A3 reached criterion in the first (errorless) phase of intervention after five sessions, immediately responded at 100% correct in the first session of phase 2 of intervention, but then made several errors during the first post-intervention probe with animals. He was then given an additional phase 2 intervention session and performed at 100% correct. He then responded successfully on post-intervention probes for the trained and generalization categories. He then demonstrated maintenance of both trained and generalization class inclusion skills in a maintenance probe conducted six weeks after the post-intervention probe.

In this study, all participants were successfully trained in a repertoire of class inclusion that showed generalization and maintenance across several stimulus sets. This is the first study to successfully implement training procedures for class inclusion responding with individuals with a diagnosis of autism. Given the dearth of literature in this area, this study provides useful information regarding effective procedures for the facilitation of this repertoire in this and other populations, and adds to the limited amount of research into the facilitation of class inclusion responding more generally.

Training Class Inclusion

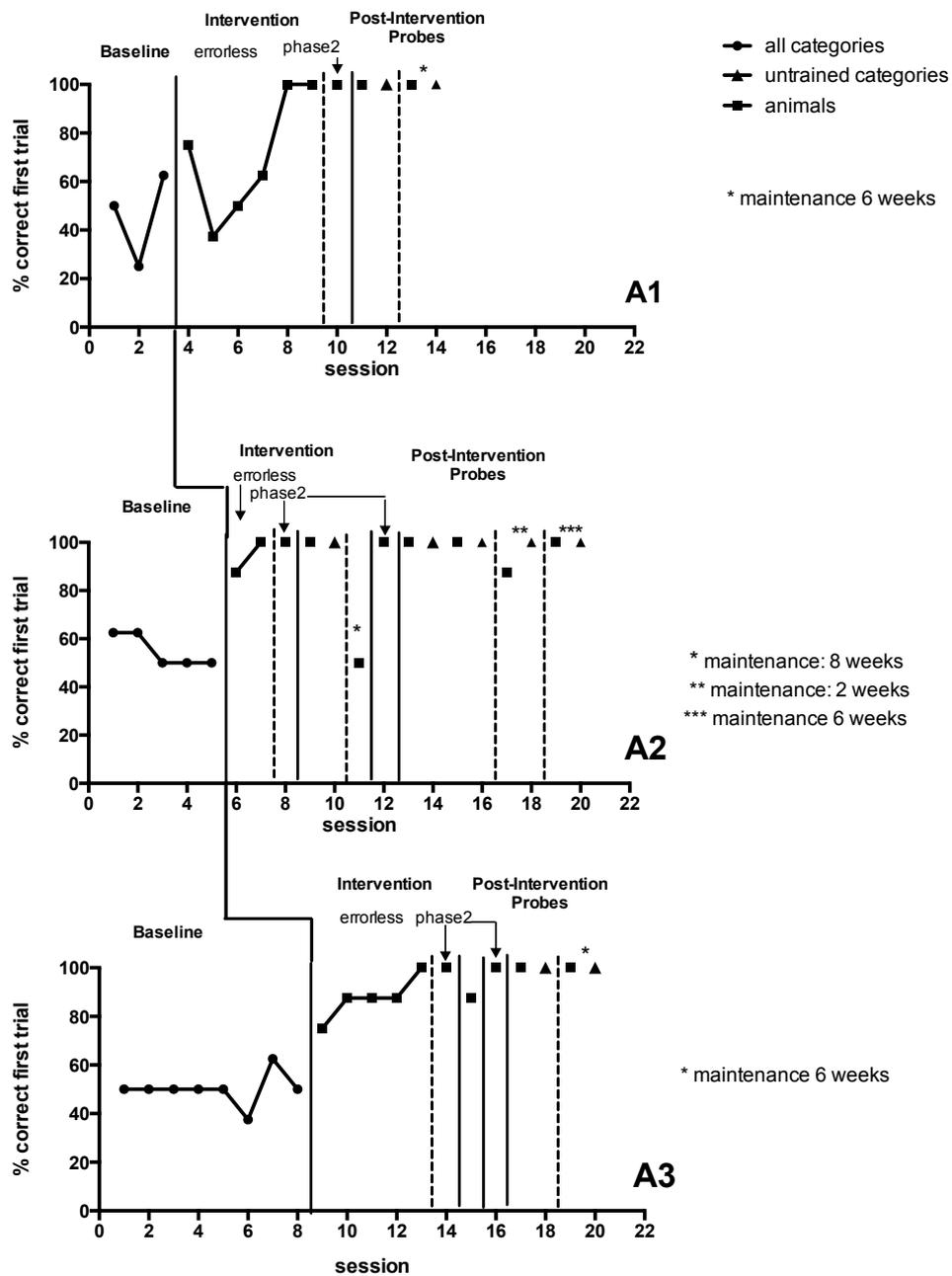


Figure 9.5. Results for first trial for each of the eight class inclusion questions for individuals with autism, participants A1, A2, and A3. Chance responding would be indicated by 50% correct.

General Discussion

As discussed in the introduction to this chapter, class inclusion is seen by many in mainstream psychology as an important milestone. In particular, Piagetian psychologists see this skill as an important indicator of cognitive development. Within RFT also, the repertoire trained in this study would be seen as important. From the RFT point of view, this particular repertoire is a pattern of non-arbitrary relational responding that should support the more abstract repertoire of hierarchical relational framing, which in turn is seen as the core skill involved in categorization. Thus, while important in its own right, class inclusion would be seen within RFT as part of a broader and very important cognitive repertoire.

Also as discussed in the introduction to this chapter, categorization skills have primarily been addressed within ABA programs strictly from the perspective of associating names of stimuli with names of the categories the stimuli belong to. However, it could be argued that if children don't understand the relations *between* categories and members then they cannot fully understand categories. It is possible that without the kind of non-arbitrary relations emphasized by this protocol, children's repertoire would be inadequate, and that without this repertoire, teaching a category name might simply be like teaching a different name for the same object. In fact, the pattern of responding seen with several of the participants in these studies would seem to bear this out—responding during baseline reflected a pattern of stimulus control that appeared to indicate that the participants were responding simply on the basis of the quantity of each stimulus type, and were comparing the stimulus type asked about to the other stimulus type rather than the larger category, as if the category was irrelevant to the relation. Once intervention was begun, the participants' performances immediately began to reflect responding in accordance with the relation between the category and the particular stimulus type/subcategory referred to in the question, rather than in accordance with the relation between the two stimulus types/subcategories. Teaching the relevant non-arbitrary containment relations likely provides a critical level of support.

There are a number of ways in which the current work might be extended. First, it would be useful to gauge how class inclusion responding might interact with

Training Class Inclusion

other repertoires. For example, might training in class inclusion skills such as trained here have a noticeable influence on children's classification repertoire more generally (as assessed by such mainstream instruments as the Children's Category Test [CCT; Boll, 1993] or similar) or might broader more extensive training in hierarchical categorization relations be needed? It would also be beneficial to determine if training in class inclusion might facilitate other repertoires of hierarchical responding, such as the types of tasks used in Newsome et al.'s (2014) study examining the effect of same/different and hierarchical training on reading comprehension (as discussed in the previous chapter).

A second question concerns the efficiency of the training used. Future research should examine the role of components of the intervention such as, for example, the use of the nested boxes as a means of highlighting the relation of non-arbitrary containment. This feature of the training was developed based on the RFT concept that non-arbitrary containment is critical for understanding more abstract hierarchical classification. However there is a question as to the extent to which successful intervention for class inclusion responding relies on this element.

A third issue is the extent to which this repertoire relies on other forms of relational responding. Particular repertoires were checked that were clearly critical such as non-arbitrary more/less relations. However, it would be informative to have a more complete assessment of other non-arbitrary and arbitrary repertoires in accordance other relations, including distinction. Moreover, for this study candidates with autism were pre-screened to identify those that had a pre-existing level of skills that seemed to indicate that they would respond to this intervention. Future work should assess children at a range of different levels of previously demonstrated performance to find out at what point this kind of repertoire has been acquired as well as to find children for whom it is difficult to acquire this repertoire. The participant in Study 9.1, for example, who did not show the improvements that the participants in Study 9.2 did, had a lower age-equivalency score on the PPVT (5-3, as opposed to 6-5 or higher). The PPVT might capture important language skills that could be needed to respond successfully to training in class inclusion. There may also be other important relational responding skills that could be considered

prerequisite to being able to learn this task, and having a broader assessment of children's existing skill sets would allow better identification of students who would benefit from this type of training as opposed to training other skill sets first.

In summary, while this is preliminary work, it represents the first explicitly RFT-based studies into classification in children. While there is much yet to be examined with respect to the full range of hierarchical relational responding, the results contribute to our understanding of early emergent relational responding repertoires, and are promising for future curriculum development for language intervention for children with autism.

Chapter 10
General Discussion

General Discussion

The work of this thesis arose from a question: how can we best ensure that our teaching procedures lead to *generative* language, rather than simply rote responding? Phrased another way, how do children learn to understand statements they have never heard before, and say things they've never said before? While behavior analysts have long recognized the importance of generative language, traditional behavior analytic approaches have not addressed this problem adequately. However, recent research on derived stimulus relations has had as a primary emphasis the emergence of such novel, untrained responses, and thus, in the course of my research I looked to the literature on derived relational responding in first exploring possible answers to these questions.

Within the field of derived stimulus relations, Relational Frame Theory (RFT; Hayes, Barnes-Holmes & Roche, 2001) in particular provides a conceptually systematic view of linguistic generativity that is key to the aim of the current work: RFT sees the core process involved in generative language as generalized, contextually controlled, arbitrarily-applicable derived relational responding, and there is much empirical evidence for this view (see Dymond & Roche, 2013 for a review). DRR appears to underlie many language and cognitive skills (see, e.g., Cassidy, Roche & Hayes, 2011; O'Hora, Pelaez, & Barnes-Holmes, 2005; O'Toole & Barnes-Holmes, 2009), and it is also extremely generative (see, e.g., O'Hora, Barnes-Holmes, Roche, & Smeets, 2004; Stewart, Barnes-Holmes & Roche, 2004; Wulfert & Hayes, 1988). Moreover, from an RFT perspective DRR is an operant that is learned through a history of multiple exemplar training over the course of natural language interactions with parents and caregivers—and, therefore, it can be taught. These characteristics suggest that identifying effective ways of training DRR may be critical to programs that focus on teaching generative, flexible language skills. Thus, this thesis set out to advance the research on early emergent derived relational responding repertoires. The primary focus involved the assessment and training of very early repertoires of DRR when such skills are weak or nonexistent—in particular, skills that are critical for the development of early language and conversation. Such repertoires emerge quickly and quite early in typical

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development, but are often very weak in individuals with autism and other developmental disabilities. It should be noted though that by focusing on populations for whom these repertoires emerge more slowly, it is possible not only to take the practical perspective of developing training procedures to remediate any deficiencies, but also to shed light on the ways in which DRR might develop in general. Hence, while most of the work in this thesis was conducted with individuals with autism, the conclusions reached may be much more broadly applicable and shed light on early language development more generally.

Summary of the Thesis

The work presented in this thesis aimed to further the research on very early emergent forms of DRR, establishing repertoires of *generative* verbal behavior rather than taught or “rote” responding. As such, Chapter 2 presented the main behavior analytic approaches that have traditionally been used to teach language skills, and made the argument that none of these approaches provides a conceptually systematic framework for establishing generativity, while DRR accounts of language do. As presented further in Chapter 3, RFT considers that language involves generalized, contextually controlled, arbitrarily-applicable relational responding. RFT argues that non-arbitrary relational responding provides the foundation for later relational framing, including the establishment of contextual control over responding on the basis of different patterns of relations among stimuli, and there is evidence for a wide range of such patterns of responding, or *relational frames*. RFT thus provided the theoretical basis of the empirical work in this thesis, and the framework of RFT also provided the organizational structure for the two main reviews of the literature presented within the thesis.

Chapter 3 presented a broad review of the literature on DRR as applied to teaching individuals with developmental delay. In addition to describing research that used existing DRR skills to more efficiently teach and facilitate generative language in various contexts, research was presented in which new repertoires of DRR were established, for a number of different relational frames. On the basis of this review, recommendations for the establishment of a number of different patterns

of relational responding were provided. In addition, a number of recommendations for future research were provided both on the basis of the literature review as well as recommendations that have been made by others, most notably Rehfeldt (2010, 2011), that shaped the work in this thesis. These included the use of natural language contexts, the use of auditory as well as visual stimuli, the examination of generalization and maintenance, the incorporation of a synthesis of Skinnerian verbal behavior with RFT, and the need to look beyond equivalence in order to broaden the repertoire of DRR skills available and facilitate relatively more complex language and academic skills. Subsequently, the thesis presented empirical research into three distinct yet related patterns of relational responding, namely coordination, distinction, and hierarchy.

Coordination

The frame of coordination is the earliest pattern of relational responding to develop and was the first one explored in this thesis. In this frame, stimuli are “substitutable” for one another—this is the pattern of stimulus equivalence, and there are now decades of research on the demonstration of stimulus equivalence with a variety of populations. However, there is very little research on how to *establish* frames of coordination with individuals who are at very early levels of language development, particularly with auditory or vocal stimuli (i.e., combinatorially entailed derived intraverbals). Much more work is needed in this domain, and the aim of this thesis was to contribute in this respect. Nonetheless, the existing literature on stimulus equivalence holds critical information for *assessing* DRR in frames of coordination, which is a necessary first step before developing training procedures.

Assessing frames of coordination. The studies in this thesis used the Training and Assessment of Relational Precursors and Abilities (TARPA; Moran, Stewart, McElwee & Ming, 2010, 2014; Moran, Walsh, Stewart, McElwee & Ming, 2015) as an assessment as well as training tool (and the TARPA was also developed further as the needs of each study required). Chapter 4 discussed the TARPA and reviewed the literature on potential variables that might affect the assessment of DRR repertoires in students with very early language abilities. Research on

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procedural variables that are more or less likely to lead to demonstrations of equivalence and derived relational responding more generally in both typically developing populations as well as populations of individuals with disabilities thus informed our decisions about assessment procedures and modifications to the TARPA for the current line of research. The impact of several of these variables, including instructional context and stimulus type, were then investigated further in order to determine the most supportive protocol for assessment and training when working with very early learners, while still maintaining control with respect to participants' previous learning histories.

The studies that focused on the effect of context, as presented in Chapter 5, highlighted the importance of careful, individualized assessment of derived relational responding repertoires. In these studies, participants who were unable to demonstrate derived intraverbals when provided with abstract stimuli in a neutral match-to-sample context were able to do so under other circumstances, particularly within the context of a game about animals and the sounds they make. The use of familiar stimuli was also facilitative and necessary for some participants, as was the use of topographical responding. While one of the studies in this chapter (Study 5.2) presented an ABAB reversal study demonstrating the effect of context alone on the performance of the participant with respect to deriving relations, the other studies were less well controlled. For these and other reasons as will be described below, future work is clearly needed to further examine and isolate these variables. Nonetheless the work in Chapter 5 resulted in several important decisions with respect to assessment in the research that followed, and also provided additional support for the contention that DRR is a contextually-controlled repertoire, learned through a history of multiple exemplar training (MET).

With students who are at a very early emergent stage of their relational responding repertoire, the core skills involved in this repertoire may be very fragile and highly sensitive to a number of variables, including the context that is established during the assessment. Thus it was these studies that confirmed the decision to use a meaningful natural language context throughout the subsequent research on training DRR (not only with respect to frames of coordination but for the

other relational patterns as well). The studies on assessment variables presented in Chapter 5, along with the first case study presented in Chapter 6, also led to (i) the addition of familiar stimuli to the TARPA as an assessment and training tool, and (ii) the decision to require topographical responding along with selection-based responding, when working with early learners.

Training frames of coordination. As noted, RFT considers DRR to be established through MET, and evidence for the effectiveness of MET was presented in Chapter 3's review of the literature on DRR. On that basis, it would be recommended that if a student cannot demonstrate a particular repertoire of derived relational responding, then curricular programming should focus on establishing those skills through multiple exemplar training of the relevant pattern of responding. As part of the current program, MET procedures for establishing DRR were developed in the context of each of the framing repertoires considered. Chapter 6 reported work that focused on such training in a frame of coordination.

As reported in Chapter 6, MET in the relevant pattern of tact-listener-intraverbal responding successfully established combinatorially entailed derived intraverbals in the context of the game about animals and the sounds they make, for two children with ASD. Over the course of two studies, teaching procedures were developed, modified, and tested. On the basis of the first case study in this chapter (Study 6.1) as well as the work described above from Chapter 5, the protocol tested in the second study on MET for coordination (Study 6.2) used familiar (rather than abstract) stimuli within the context of the animal game. Modifications to the initial protocol also included MET in all the relevant relations: tact, listener, and intraverbal responses, rather than focusing only on the intraverbal relations. This final protocol resulted in the rapid acquisition of generalized combinatorially entailed intraverbals for one participant, and the immediate improvement in derived intraverbal responding for the second. While only preliminary research, this is the first demonstration of MET for combinatorially entailed derived intraverbals using auditory stimuli, and also adds to the heretofore quite limited evidence of the effectiveness of MET in establishing DRR in frames of coordination when working with individuals at very early levels of language development .

Distinction

The second frame examined in the current program was distinction—that is, relating stimuli on the basis of difference, rather than sameness. Generalized responding in accordance with sameness *and* difference has long been considered a critically important skill for both language and academics, and can be considered an important behavioral cusp (McIlvane, 2011). However, in comparison to the body of literature on equivalence and identity matching, there is relatively little applied behavioral research on distinction at either the non-arbitrary (physical) or arbitrary (abstract) relational level. Chapter 7 presented a review of the literature on same/different responding, including responding in accordance with frames of distinction, from a variety of domains, including: comparative psychology, experimental and translational behavior analysis, Skinnerian verbal behavior, and RFT. In this chapter, a number of recommendations were made for future research as well as clinical practice; however, many of the recommendations with respect to teaching procedures and curricular sequencing have not yet been well researched, and there is much future work to be done. Some of the recommendations to come out of this review were in line with the earlier literature review with respect to teaching relational responding more generally: that is, the use of multiple exemplar training in the relational pattern of responding, as well as the use of non-arbitrary training as a foundation for arbitrary relational responding. These recommendations informed the work in Chapter 8.

Assessing and training frames of distinction. In Chapter 8, establishing DRR in a relation of distinction was explored, and early pilot work with children at a variety of different skill levels led to the development of a game that involved learning about animals and the food that they liked, with the animals liking the same or different food from each other. The game was developed for providing assessment and MET of both non-arbitrary and arbitrary relations of same/different among the animals. The game was then used to establish a pattern of DRR skills in combined frames of coordination and distinction for several children with ASD. Through the course of two case studies (Studies 8.1 and 8.2), the assessment and training protocol

was developed, with the latter involving MET in the relevant pattern of responding with multiple food stimulus sets. This intervention resulted in the participant in Study 8.2 as well as the two children in a multiple baseline study (Study 8.3) acquiring the DRR skill with novel stimulus sets; all the children also were able to generalize this repertoire to a simple test of reading comprehension.

The assessment of DRR used in these studies was slightly unusual in comparison to previous work, in that instead of assessing the relevant relations as was done in the studies on coordination in Chapter 6 (e.g., A-B, C-B, A-C), transformation of function was tested, and then trained when found to be deficient. There have been studies of derived manding (e.g., Murphy, Barnes-Holmes & Barnes-Holmes, 2005; Murphy & Barnes-Holmes, 2010) in which training in transformation of function was used to establish DRR for some participants (those who were not able to demonstrate derived manding following training in the baseline relations). Study 8.3 used a multiple baseline design to provide a controlled demonstration of the utility of MET specifically with respect to establishing appropriate derived transformation of function. Moreover, it is the first study to establish a pattern of DRR with children with autism in the context of combined same/difference.

Hierarchy

Following on from the studies on frames of distinction, the final relational pattern studied was that of class inclusion, which, from the RFT perspective guiding the present research, falls under the umbrella of hierarchical relations. Class inclusion requires an individual to respond to a stimulus as simultaneously belonging both to a class as well as to a subclass contained in it, and can be viewed as a non-arbitrary relational skill underlying hierarchical relational framing and advanced categorization skills. Like distinction, categorization has long been recognized as critical for language and concept learning, and although there is relatively little applied behavioral research on categorization, there has been important behavioral work that has focused on categorization in terms of derived equivalence (Miguel, Petursdottir & Carr, 2005; Miguel, Petursdottir, Carr & Michael, 2008; Petursdottir,

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Carr, Lechago & Almason, 2008; Miguel & Kobari-Wright, 2013; Kobari-Wright & Miguel, 2014). However, this is a relatively basic level of categorization, and does not imply a hierarchical relation among the stimuli. Nevertheless, categorization as a concept does imply hierarchical organisation and thus this is a key element to include in training. DRR in a frame of hierarchy is quite an advanced skill, but it rests on many other relational responding skills, including coordination and distinction as well as non-arbitrary relational responding. Given the focus of the thesis on exploring early emergent DRR, class inclusion was chosen as a relevant non-arbitrary relational skill to examine with respect to hierarchical relations.

Assessing and training class inclusion. In Chapter 9, MET that focused on a non-arbitrary relation of containment was used to establish a generalized class inclusion repertoire as a foundation for hierarchical relational responding. The teaching procedures were based on previous work with typically developing children, and then tested and modified over the course of a single case study (Study 9.1) to make the relation of containment more salient by using nested boxes to represent the category and subcategories of stimuli. This teaching protocol was then tested further using a multiple baseline design (Study 9.2) with three typically developing preschoolers. Following the success of the MET intervention with the typically developing children, it was tested in a multiple baseline design (Study 9.3) with three children with autism. The intervention resulted in all three children rapidly acquiring, generalizing, and maintaining the class inclusion repertoire. This is the first study which has examined class inclusion in children with autism, and the study with typically developing preschoolers also adds to the existing literature with that population with respect to the generalization and maintenance of this skill following training.

Implications and Directions for Future Research

The studies presented in this thesis extend the literature on the emergence of early patterns of derived relational responding in a number of ways. Firstly, socially valid assessment tools for identifying relational responding repertoires with respect to coordination, distinction, and class inclusion were developed. These assessments

allowed for the identification of abilities with individuals even at very early developmental language levels. In addition, several of the studies add to the existing body of research on the efficacy of MET in the relevant relational pattern for establishing DRR across various frames (e.g., Barnes-Holmes , Barnes-Holmes, Smeets, Strand & Friman, 2004; Berens & Hayes, 2007; Gorham, Barnes-Holmes, Barnes-Holmes & Berens, 2009; Greer & Ross, 2008; Luciano, Gomez-Becerra & Rodriguez-Valverde, 2007). These studies also support Luciano et al.'s (2009) recommendations with respect to the importance of MET in the establishment of the earliest patterns of relational responding. As such, they provide further support for the contention made by RFT that derived relational responding can be explained as a contextually controlled repertoire established based on multiple exemplar training provided in the course of (typically natural) language interactions.

These studies have also addressed a number of research priorities identified by Rehfeldt (2010, 2011). These priorities have included examining DRR with respect to auditory stimuli, given the importance of auditory-visual stimulus relations to being able to understand spoken language: all the studies incorporated auditory and/or vocal stimuli and response forms, rather than solely visual, and used natural language contexts. The studies on coordination in particular also took the perspective of a synthesis of Skinnerian verbal behavior and RFT, with respect to establishing derived intraverbal responding following training in tact or listener responses. The studies on both coordination and distinction further examined the generalization of training protocols delivered on the iPad in selection-based formats to more typical table-top teaching formats; the findings from these studies touched on variables such as topography versus selection based responding and real life versus abstract stimuli that might be examined more systematically in future work. Rehfeldt also noted that it is critical to examine frames beyond equivalence in order to develop teaching procedures that are relevant to more complex academic skills. The current line of research has represented a beginning step in that direction. In Chapter 8, one of the earliest emergent DRR repertoires beyond sameness was examined in the form of combined same/different responding, as well as exploring the generalization of that skill to a simple test of reading comprehension. The research presented in Chapter 9

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examined an early categorization skill—class inclusion— that may be foundational for more complex hierarchical relational responding.

Nonetheless, there is still much work to be done, and these studies should be considered preliminary. Particularly the work on early coordinate framing (Study 6.2) needs replication with better experimental control, given that only two participants were involved in that study, for each of whom there were slightly different procedures for establishing baseline relations. For all of the studies, future work is needed to replicate the results with additional participants, examine the utility of and generalization of the MET interventions to additional language and instructional contexts, and test for the effects of each of the interventions on broader measures of language and cognitive skills.

In addition to studying the generality of the teaching procedures developed and tested in these studies, however, both the research conducted as well as the broader literature reviews have highlighted numerous additional areas that might prove fruitful for future research. This includes potential areas to explore both with respect to specific frames as well as with respect to the interactions among relational responding repertoires, which will be described below as relevant to each of the relational patterns explored in this thesis and more generally.

Coordination

Training format. As described in Chapter 4, the format of training the baseline relations prior to testing for DRR may have an effect on the likelihood of DRR being demonstrated. Some studies have shown that using a many-to-one training format (e.g., train A-B and C-B, and then test A-C) may be more likely to result in demonstrations of DRR (Saunders, Wachter & Spradlin, 1988; Spradlin & Saunders, 1986; Barnes, 1992 as cited in Barnes, 1994; Arntzen & Vaidya, 2008), while others have found the opposite or no effect (Arntzen & Holth, 2012; Smeets & Barnes, 2005). Moreover, when working with auditory-visual relations of the type examined in the studies in Chapters 5 and 6 (two auditory and one visual, with the combinatorial entailment test being between the two auditory stimuli), the issue of training tact vs listener skills provides further complication, since in general it has

been found that training tacts (which in this case would require a one-to-many format) is more likely to result in demonstration of DRR than training listener skills (which would require a many-to-one training format) (Petursdottir & Carr, 2011; (Petursdottir, Olafsdottir & Aradottir, 2008; Sprinkle & Miguel, 2012).

In Study 6.2, two formats for training the initial baseline relations were used: one in which the baseline relations were trained as tacts, and then mutually entailed listener relations and combinatorially entailed intraverbals were tested, and the other in which the baseline relations were trained as listener responses, with mutually entailed tact and combinatorially entailed intraverbals tested. Results in terms of participants' demonstrations of DRR during baseline did not seem to favor one format over the other. Both formats resulted in improvements in DRR following intervention, although the participant receiving listener training (using a many-to-one format) in baseline relations did have greater and more rapid improvements. At the same time, of course these data are indicative only. Further better controlled work comparing the formats systematically across multiple subjects is needed to determine whether one or the other training format is more efficient for MET to establish frames of coordination among auditory and visual stimuli.

Response form. The issue of topographical vs selection-based responding is also a critical area to examine with respect to the emergence of early DRR repertoires. Particularly if computer-based training applications are targeted at this very early learner population, it is essential to determine if responding in such formats is significantly impacted by the response form required. The only research on this topic has shown conflicting results, and each study worked with very different populations and different topographical and selection-based response forms. None have examined the use of vocal topographical responses vs the selection of auditory stimuli.

Curricular sequencing. Finally with respect to frames of coordination, there is the question of when to begin including MET to establish a repertoire of DRR, as opposed to working exclusively on other important early learning skills and teaching an initial repertoire of taught mands, tacts, intraverbals and listener skills. Ensuring that teaching targets are coordinated across these repertoires from the beginning

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would be a sensible place to start, but further work is needed to determine when to more intensively and systematically focus on teaching patterns of responding to establish derived mands, tacts, listener responses, and intraverbals (or if such MET should be incorporated from the beginning of an intervention program). Common sense would suggest that while frames of coordination do emerge quite early in typically developing young children, the ability to rapidly acquire new conditional discriminations among auditory and visual stimuli (i.e., tacts and listener responses, and potentially early intraverbal responses) might be necessary first. However, there is no research to guide the practitioner as to when to shift teaching from a focus on building “vocabulary” (e.g., in the sense of a tact repertoire) to a greater focus on building DRR skills.

Distinction

Extending to more advanced DRR repertoires. The studies presented in Chapter 8 primarily focused on a relatively simple level of DRR in terms of relations of coordination and distinction. In these studies, training specifically for combinatorial entailment was not examined, and extending the research to include this level of DRR is necessary for looking at more advanced repertoires. Additionally, the research looked at combined frames of coordination and distinction, and MET for establishing frames of distinction alone should be studied as well with participants who have more advanced language skills.

Training format. The studies in Chapter 8 also highlighted a need for further exploration of the format of training that would be most efficient for establishing baseline relations and leading to demonstrations of DRR when working with combined frames of coordination and distinction, and perhaps more generally with other frames as well. In these studies, two training formats were used to establish and strengthen baseline relations prior to DRR testing. One format involved a more typical conditional discrimination training, in which participants selected a stimulus on the basis of another stimulus and the cue for the relation (e.g., given the SD “the lion likes DIFFERENT from...”, select bear). The other format involved training a relational tact (e.g., given the stimuli of the lion and the bear, select DIFFERENT).

Training in the relational tact alone did not result in the participants being able to demonstrate DRR, but future research might isolate these training variables.

Non-arbitrary relational responding. The work presented in Chapter 8 with respect to same/different responding also highlighted the need to ensure fluent non-arbitrary relational responding within a particular frame before teaching arbitrary relational responding, an issue that has come up in previous studies of DRR (e.g., Barnes-Holmes et al., 2004; Berens & Hayes, 2007; Gorham et al., 2009). RFT suggests that non-arbitrary relational responding is a very important foundation for arbitrary responding (as discussed in Chapter 9 with relation to hierarchy). However, there is no research as yet to guide the practitioner in terms of when to shift from a focus on teaching and strengthening non-arbitrary same/different responding to teaching arbitrary relational responding in this (or any other) frames. Identifying a range of non-arbitrary relational responding skills that may make acquiring a repertoire of arbitrary DRR more likely would be very informative and help ensure appropriate sequencing of curricular goals.

Hierarchy

Training format. The protocol used for training the class inclusion skill in the research in Chapter 9 was quite lengthy, and included extensive instructional prompting as well as the physical boxes. While it did result in fairly rapid acquisition of the skill, compared to the initial use of a two-dimensional protocol, it is difficult to say which of the elements would be necessary and sufficient to train the repertoire. There may be more efficient methods of training, and the difficulty the participant in the first study had may have been more due to his individual learning history and pre-existing skills (he did have an earlier level of language skills) than due to the two-dimensional nature of the original protocol. Testing simpler protocols that nonetheless highlight the containment relation, with participants at the same language level as those for whom the protocol from Chapter 9 was successful, would provide insight into the essential elements of an MET intervention for this skill.

Relation of class inclusion to hierarchical framing and categorization. Class inclusion was chosen as a potentially relevant non-arbitrary relational response

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repertoire to train that mainstream psychology sees as a particularly important marker of language and cognitive development, and which would be seen by RFT as an important non-arbitrary foundation for hierarchical framing in its own right. However, it is not clear to what extent training in class inclusion might affect other, broader skill sets. One extension of the current research would be to use a broader test of categorization skills, and determine whether training in class inclusion would also result in improvements on categorization as measured on a standardized assessment such as the Children's Category Test (CCT; Boll, 1993). Another extension of the current research would be to examine how training in class inclusion might facilitate learning other, arbitrary relational responding skills related to hierarchy (such as might be seen in tests of reading comprehension, as examined by K.B. Newsome, Berens, Ghezzi, Aninao, and W.B. Newsome [2014]).

Interactions among relational responding repertoires

All of the studies, while showing good results with respect to generalization (and in the case of the class inclusion studies, maintenance) of that specific repertoire, raise the question of how learning that repertoire impacts other important skills. For example, how does gaining a repertoire of class inclusion affect the acquisition of a larger repertoire of hierarchical relational responding, as well other repertoires such as distinction or comparison? This is a question that can be asked more generally—much further study is needed to clarify the interaction of the non-arbitrary and arbitrary relational responses in the development of each of the frames studied in this thesis, as well as other early emergent relations, such as opposition, comparison, and spatial relations. As noted in Chapter 7 with respect to relations of difference, the literature on non-arbitrary relational responding crosses several disciplines, and there has been no research examining the best sequence of training non-arbitrary and early arbitrary relational responding.

In addition, there has been no research examining how repertoires of non-arbitrary and arbitrary relational responding across multiple frames might interact with one another and with broader skill sets. For example, would a stronger and more flexible repertoire of non-arbitrary same and different responding improve not

only arbitrary responding in frames of coordination or distinction, but also DRR in frames of opposition, comparison, or hierarchy? Would training in either non-arbitrary or arbitrary responding across multiple relational frames impact other relevant skill sets and broader measures of language and cognitive skills? Such broader skills might be assessed through both quantitative and qualitative narrative language assessment (e.g., see Hughes, MacGillivray & Schmidek, 1997) as well as standardized language and IQ measures and academic assessments (such as for reading comprehension). There is evidence (Cassidy, Roche & Hayes, 2011) to suggest that training which strengthens DRR across multiple frames can increase general IQ scores, but thus far this result has only been shown with individuals who likely already have a repertoire of DRR. More work is needed to determine the broader impact of teaching relational framing skills to individuals who do not yet have them. Intuitively, the acquisition of a repertoire of DRR should have a clear positive impact on the learning of language in the natural environment and increase flexibility and generativity of verbal behavior, but this remains to be studied.

Summary and Conclusions

The research presented in this thesis has advanced the work on early emergent DRR, but is still preliminary in many respects—there are many potential avenues for further study, as discussed above and in the literature reviews presented in Chapters 3 and 7. Although there is much work yet to be accomplished, the current research has achieved its primary aim: to explore repertoires of derived relational responding with children with autism, and in particular to establish such repertoires in individuals with very low levels of language and derived relational responding repertoires. The studies presented here have included the first reversal effect seen in deriving intraverbals in a frame of coordination based on instructional context alone; the first demonstration of a teaching protocol for establishing frames of coordination based on derived tact, listener and intraverbal responding, with individuals at a very early language level; the first study to establish a new repertoire of DRR skills in combined frames of coordination and distinction, including generalization to a simple test of reading comprehension; and the first study to train

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class inclusion with children with autism. Moreover, these demonstrations have provided further support for contentions made by RFT that are critical to the development of curricula for establishing DRR. Firstly, they provide support for derived relational responding as a generalized operant, learned through a history of multiple exemplar training. As such, training DRR can be seen as a critical component of any program of language development. The experiments in this thesis also provide additional support for the supposition that while derived relational responding involves contextually-controlled arbitrary relations, it is likely rooted in a repertoire of *non*-arbitrary relational responding. Training non-arbitrary relational responding is not often an explicit focus of programs for children with autism, but both the literature reviewed and studies conducted in this thesis would suggest that it is an important foundational skill for DRR.

Perhaps equally importantly, the research presented in this thesis has resulted in the development of promising and practical assessment and teaching tools for behavior analysts working with children with autism. As Rehfeldt (2011) notes, the technology of derived stimulus relations research must be able to be disseminated to practitioners if it is to have the socially significant impact we hope for. It is hoped that the studies and reviews that form this thesis have provided another step towards that goal, not only by showing the efficacy of an RFT approach but also by providing an exemplar of the integration with existing approaches. Both Lovaas-based and Skinnerian verbal behavior programs have a strong evidence base and much to recommend them, and ABA-based programs for children with autism have evolved significantly over the years to incorporate new evidence-based teaching procedures. DRR researchers should recognize the value of these approaches and offer a technology to complement rather than replace existing practices. In order to achieve wider-scale adoption, the technology developed and disseminated on the basis of DRR research must be practitioner-friendly, and should not require such a high response effort either to implement or understand as to render it unusable: as with the protocols developed in this thesis, procedures must be able to be implemented in standard table-top teaching formats or using an easily-managed iPad app, and use materials and contexts that are understandable and familiar to early interventionists.

However, more than just lesson plans or apps are needed. Most importantly, the technology must be used in real-world settings, and practitioners must see results. All of the studies conducted in the course of this thesis were conducted in applied settings, and many were implemented by the behavior analysts and teachers in those settings. As more practitioners are exposed to teaching programs based on DRR research, and have success with their implementation, that is when we can expect ABA programs for children with autism to incorporate teaching DRR as a critical component in delivering evidence-based services.

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Appendix A: TARPA Tracking Sheets

Appendix A

Stage 3: Conditional Discrimination—Formally Dissimilar Stimuli Track: Auditory-Visual 2 ____AV2i: derived listener ____AV2ii: derived tact Stimulus set # _____ ◀ AI (pic) BI ◀ CI ◀ A2 (pic) B2 ◀ C2 (See stimulus set table)						
Continue testing until a training or maintenance section is failed twice within a stage, or until a derivation test level is failed						
Level	Section	Date	Session Start/End	Pass Criteria (Default)	Result	Notes
1 CD	Train A→B			5/6 (end on correct trial)		
2 ME	1 Train A→B			5/6 (end on correct trial)		Optional level if continuing on directly from Level 1
	2* Maint. A→B			4/4		
	3* ME Test B→A			5/6		
	4 Train C→B			5/6 (end on correct trial)		
	5* Maint. C→B			4/4		
	6* ME Test B→C			5/6		
3 CE	1 Train A→B			5/6 (end on correct trial)		Optional level if continuing on directly from Level 2
	2* Maint. A→B			4/4		Optional level if continuing on directly from Level 2
	3 Train C→B			5/6 (end on correct trial)		Optional level if continuing on directly from Level 2
	4* Maint. C→B			4/4		Optional level if continuing on directly from Level 2
	5 Train A→B,C→B			7/8 (end on correct trial)		
	6* Maint. mixed			8/8		
	7* CE Test C↔A			7/8		

Appendix A

Section 3: Conditional Discrimination—Formally Dissimilar Stimuli

Track: Auditory-Auditory

Stimulus set # _____

 AI
  BI
  CI
  A2
  B2
  C2

Continue testing until a training or maintenance section is failed twice within a stage, or until a derivation test level is failed.

Level	Section	Date	Session Start/End	Pass Criteria (Default)	Result	Notes
1 CD	Train A→B			5/6 (end on correct trial)		
2 ME	I Train A→B			5/6 (end on correct trial)		Optional level if continuing on directly from Level 1
	2* Maint. A→B			4/4		
	3* ME Test B→A			5/6		
	I Train C→B			5/6 (end on correct trial)		
	2* Maint. C→B			4/4		
	3* ME Test B→C			5/6		
3 CE	I Train A→B			5/6 (end on correct trial)		Optional level if continuing on directly from Level 2
	2* Maint. A→B			4/4		Optional level if continuing on directly from Level 2
	3 Train C→B			5/6 (end on correct trial)		Optional level if continuing on directly from Level 2
	4* Maint. C→B			4/4		Optional level if continuing on directly from Level 2
	5 Train A→B,C→B			7/8 (end on correct trial)		
	6* Maint. mixed			8/8		
	7* CE Test C↔A			7/8		

DIFFERENT: TARPA TRACKING
Topographical Pretest

Date/ Ssn #	Set 1 S / D	Set 2 S / D	Set 3 S / D	Set 4 S / D	Set 5 S / D	Set 6 S / D	Total
1							

Tracking: Baseline—ME ToF

Date/ Ssn #	Set 1 S / D	Set 2 S / D	Set 3 S / D	Set 4 S / D	Set 5 S / D	Set 6 S / D	Total
1							
2							
3							
4							
5							
6							
7							

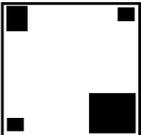
Tracking: Intervention

Date/ Ssn #	Set 1 S / D	Set 1 # of food sets	Set 2 S / D	Set 2 # of food sets			Total
1							
2							
3							
4							
5							

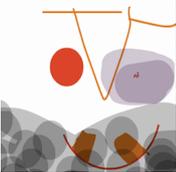
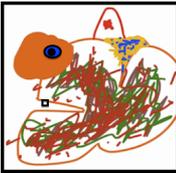
Appendix A

Appendix B: TARPA Stimulus Sets

Appendix B

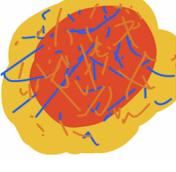
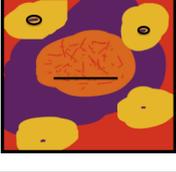
A (aud)	B (vis)	C (aud)
Abstract Black & White Stimulus Set 1		
Cug		nem
Dib		paz
Stimulus Set 2		
tud		plik
lof		sloo
Stimulus Set 3		
vax		doh
nin		som

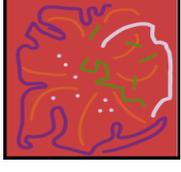
Appendix B

A (name)	B (pic)	C (sound)
Colored Abstract Stimulus Set 1		
Aps		boo
blanti		eep
Stimulus Set 2		
Blab		git
flarti		tlaw
Stimulus Set 3		
Specme		Woosh
Mro		Guff

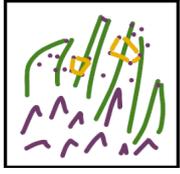
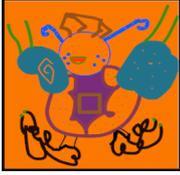
A (name)	B (pic)	C (sound)
Stimulus Set 4		
Mwak 4		Trin 4
Skit 4		Clid 4
Stimulus Set 5		
bumiie		lugg
spi		eeg
Stimulus Set 6		
lame		ikuh
mlan		sluh

Appendix B

A (name)	B (pic)	C (sound)
Stimulus Set 7		
moeeeeeeeeeee		skih
wathu		glag
Stimulus Set 8		
Murff		Cooms
xantrum		plik
Stimulus Set 9		
Sloot		bim
twiee		plop

A (name)	B (pic)	C (sound)
Stimulus Set 10		
zopz		loo
moz		kiye
Stimulus Set 11		
mid		jape
ook		zaz
Stimulus Set 12		
miloo		sall
kan		zoma

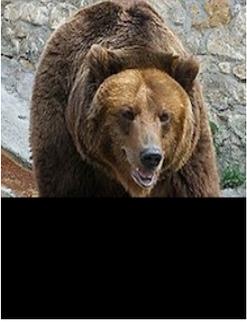
Appendix B

A (name)	B (pic)	C (sound)
Stimulus Set 13		
zeek		wowo
lom		keeya
Stimulus Set 14		
moof		klop
eekow		zem

Set: Real Life	A (name) (new)	B (animal) (known)	C (sound) (known)
Set 1	Jack		Roar
	Ted		Ssss
Set 2	Sue		Quack
	Jane		Moo
Set 3	Fred		Woof
	Joe		Meow

Appendix B

Set: Real Life	A (name) (new)	B (animal) (known)	C (sound) (known)
Set 4	Eve		Oink
	Jill		Buzz
Set 5	Sam		Baa
	Dave		Neigh

Set: Real Life	A (name) (new)	B (animal) (known)	C (sound) (known)
Set 6	Bill		Ribbit
	Jeff		Oo Oo Oo
Set 7	Lucy		Hoo hoo
	Ann		Roar

Appendix B

Set: Real Life	A (name) (new)	B (animal) (known)	C (sound) (known)
Set 8	Ed		Gobble gobble
	Bob		Meow
Set 9	Steve		Woof
	Dan		Cock a Doodle Doo
Set 10	Ellen		Tweet tweet

Set: Real Life	A (name) (new)	B (animal) (known)	C (sound) (known)
	Sara		Roar
Set 11	George		Cluck Cluck
	Don filename: Don2		Squeak
Set 12	Jim		Glub glub

Appendix B

Set: Real Life	A (name) (new)	B (animal) (known)	C (sound) (known)
	Ben		Hee Haw
Set 13	Betty		Roar
	Linda		Moo
Set 14	Ken		Ssss

Set: Real Life	A (name) (new)	B (animal) (known)	C (sound) (known)
	Rick		Neigh

Appendix B

Appendix C: Procedural Fidelity Checklists

Appendix C

TARPA Implementation Fidelity

Administrator: _____

Prior to utilizing the TARPA with research participants, administrators must demonstrate at least 90% implementation fidelity across all the types of TARPA trials (including initial DGI, error correction, and no response), and all the types of TARPA stimulus presentation formats, as outlined below.

Stage	Level/Section	Modality	# comparisons	Date Checked
I	trained	Vis Aud	Blank 2 3	
I	trained	Vis Aud	Blank 2 3	
I	trained	Vis Aud	Blank 2 3	
2 3 4 5 6 7 9	trained tested	Vis-Vis Vis-Aud Aud-Vis Aud-Aud	2 3	
2 3 4 5 6 7 9	trained tested	Vis-Vis Vis-Aud Aud-Vis Aud-Aud	2 3	
2 3 4 5 6 7 9	trained tested	Vis-Vis Vis-Aud Aud-Vis Aud-Aud	2 3	
2 3 4 5 6 7 9	trained tested	Vis-Vis Vis-Aud Aud-Vis Aud-Aud	2 3	
8 10	mand training ToF testing	Vis-Vis Vis-Aud Aud-Vis Aud-Aud	2 3	
8 10	mand training ToF testing	Vis-Vis Vis-Aud Aud-Vis Aud-Aud	2 3	
8 10	mand training ToF testing	Vis-Vis Vis-Aud Aud-Vis Aud-Aud	2 3	
8 10	mand training ToF testing	Vis-Vis Vis-Aud Aud-Vis Aud-Aud	2 3	

Appendix C

TARPA Implementation Fidelity

Participant: _____ Administrator: _____
 Stage/Level/Section(s): _____ Test Site: _____
 Date/Time of Testing: _____
 Scored by: _____
 IOR scoring: _____ Date of Scoring: _____

Trial	Fidelity	IOR
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Trial	Fidelity	IOR
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		

Trial	Fidelity	IOR
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		

Total		
Correct		
%		

Instructions:
 A trial begins with the presentation of the sample stimulus on the computer.
 Score fidelity as correct (+) if *all* elements of the assessment checklist are correct. Score fidelity as incorrect (-) if *any* elements of the assessment checklist are incorrect.
 Score IOR as in agreement (+) or not in agreement (-).

Assessment Checklist

Environmental Arrangement

- ✓ Seating appropriate for child to touch screen
- ✓ Teacher next to child

Reinforcement: Directly Trained or Maintenance Section

- ✓ Any additional reinforcement systems normally used for instruction with child are available and used on typical schedule
- ✓ Social praise provided (along with computer-delivered reinforcement if applicable)

First Trial Each Trained Relation of Directly Trained Section

- ✓ DGI gesture used to enter DGI mode
- ✓ Demonstrate: appropriate verbal instruction and accurate demonstration
- ✓ Guide: appropriate verbal instruction and prompt
- ✓ Independent trial: appropriate verbal instruction and allow up to 5s to respond
- ✓ Auditory samples replayed prior to comparison selection
- ✓ DGI gesture used to continue to next trial

Error Correction in Directly Trained or Maintenance Level

- ✓ DGI gesture used to enter DGI mode if error is made
- ✓ NO RESPONSE button pressed if no response is made
- ✓ Demonstrate: appropriate verbal instruction and accurate demonstration
- ✓ Guide: appropriate verbal instruction and prompt
- ✓ Independent trial: appropriate verbal instruction and allow up to 5s to respond
- ✓ Error correction procedure repeated accurately one time if error made at independent trial
- ✓ Auditory samples replayed prior to comparison selection
- ✓ DGI gesture or NO RESPONSE button used to continue to next trial

First Trial of Maintenance or Tested Level

- ✓ Appropriate verbal instruction to begin level

Reinforcement: Tested Level

- ✓ No specific reinforcement used
- ✓ Any verbal statements are neutral, including prompts to continue responding

Error Correction in Tested Level

- ✓ No error correction procedures are used

Auditory Stimuli

- ✓ Repeated by pressing sample if student requests or indicates need for repeat

Appendix D: Protocols

Appendix D

Teaching Protocol for Derived Intraverbals (Combinatorial Entailment—Frame: Coordination)

Goal: Student will be able to respond to a novel intraverbal question, having been taught the related tact/listener responses, as follows: after being taught A is the name of B (taught to pick picture B when told name A), and being taught C is the sound B says (taught to pick picture B when told sound C), the student will be able answer a question about what sound “A” makes or what says the sound “C”), both with selection based and topographical responding.

When to introduce:

Student demonstrates mutual entailment with auditory-visual relations

Passes TARP A Section 3, Stage 2 for Auditory-Visual Track 1

Student does not demonstrate combinatorial entailment with auditory-auditory relations based on previously learned auditory-visual relations

Fails TARP A Section 3, Stage 3 for Auditory-Visual Track 2

Materials:

Computer-based training: multiple stimulus sets on the computer consisting of abstract imaginary “animals” along with their corresponding names and sounds (as attached)

Multiple stimulus sets consisting of pictures of unusual birds or musical instruments, along with their corresponding names and sounds (as attached)

Procedure—Computer based training:

Phase 1.1: Training in Baseline Relations: Listener Responding (Name)

Begin the training by stating, “We are going to play a game to learn about some funny animals! First we will learn about what name they are called, and then we will learn the sounds they make.”

Phase 1.1a: Training

For the first trial and any subsequent incorrect trials, use the following procedure

Demonstrate

Guide

Independent trial

Demonstrate

The teacher should press the space bar to prevent advance to the next trial. The teacher should press the sample stimulus to play the sound (the name), and then state, “[name] is what this one is called” and point to the correct comparison stimulus.

Appendix D

Guide

The teacher says, “Let’s do it together” or similar phrase. The teacher should use gestural prompts or modeling to have the student press the sample to play the name, and then the teacher should state, “Which one is called [name]?” and then point to the correct comparison stimulus while the student makes the correct selection.

Independent Trial

The teacher then says, “Now you do it yourself” and prompts as necessary for the student to play the sample stimulus, and then asks, “Which one is called [name]?” and gives the child five seconds to respond.

If no response or an *incorrect* response is produced then the teacher says, “Let’s try again” and goes through the demonstration and guidance steps once again. *The demonstration and guidance steps should be repeated only one time before advancing to the next trial.*

If a *correct* response is produced then the teacher says, “Good job” or provides similar social praise.

Then the teacher presses the space bar to advance. From there onwards, the initial procedure for the *Independent* trial should be followed as needed to begin each trial. If the child gets a trial incorrect then the teacher should press the space bar; if the child gives no response then the teacher should press the ‘n’ key. The teacher should go through the DGI procedure before pressing the space bar or ‘n’ key again to advance.

Phase 1.1b: Maintenance

Reinforcement within the program is turned *off* (this is automatically done by the program). The teacher may, however, provide additional specific feedback and reinforcement (as well as reinforcement for continuing to attend to the program, see the note above regarding maintaining student motivation). If errors occur, the teacher should complete a DGI procedure as described above for training levels.

Prior to the first trial the teacher should begin by stating, “Now you try it all on your own—see if you can remember what the animals are called.” The teacher should prompt as necessary for the student to play the sample stimulus, and then ask, “Which one is called [name]?”

If the student notes the absence of reinforcement, the teacher may state “This is like a test to see if you can remember it, the computer won’t tell you if you got it right or not—let’s see if you can get to the end all on your own.”

In all cases, neutral prompts to continue responding (e.g., “You’re trying hard, let’s keep going”) may be provided. Prompts to click on the sample stimulus (e.g., “Remember, you need to touch here first”), or to make a selection (e.g., “Find the

right one”) may be provided.

When the student passes the maintenance test in Phase 1.1 (as designated by the program, this will be when the student achieves five out of six consecutive correct responses), go on to Phase 1.2. If the student does not pass Phase 1.1, contact Siri.

Phase 1.2: Testing for Mutual Entailment (Derived Tact)

Reinforcement within the program is turned *off* (this is automatically done by the program), and the teacher should not use any additional specific reinforcement (although reinforcement for continuing to attend to the program may be used). No demonstration or prompting procedures are used. For this phase, the picture of the “animal” will be the sample stimulus, and the student will press the sample to play the two auditory comparisons, which will be the names of the “animals”.

Prior to the first trial the teacher should begin by stating, “Now you try it all on your own—see if you can remember the names the animals are called.” When the sample stimulus comes up, the teacher should state, “What’s this called?” and may prompt as necessary at any time to press the sample stimulus to play the sounds.

If the student notes the absence of reinforcement, the teacher may state “This is like a test, the computer won’t tell you if you got it right or not—let’s see if you can get to the end all on your own,” (or similar neutral statement).

In all cases, neutral prompts to continue responding (e.g., “You’re trying hard, let’s keep going”) may be provided. Prompts to click on the sample stimulus (e.g., “Remember, you need to touch here first”), or to make a selection (e.g., “Find the right one”) may be provided.

When the student passes the test in Phase 1.2 (as designated by the program, this will be when the student achieves five out of six consecutive correct responses), go on to Phase 2. If the student does not pass Phase 1.2, contact Siri.

Phase 2.1: Training in Baseline Relations—Listener Responding (sound)

Begin the training by stating, “Now we are going to play a game to learn about the sounds those animals make.” Using the same procedures as in Phase 1, use the verbal instructions, “[sound] is the sound this one says” or “Which one says [sound]” as appropriate.

When the student passes the maintenance test in Phase 3 (as designated by the program, this will be when the student achieves five out of six consecutive correct responses), go on to Phase 3. If the student does not pass Phase 3, contact Siri.

Appendix D

Phase 2.2: Testing for Mutual Entailment (Derived Tact (sound))

For this phase, the sample stimulus will be the picture of the animal, and the comparison stimuli will be the sounds the animals make. Follow the procedures in Phase 2, using the verbal instruction, “What does this one say?”.

Phase 3.1: Mixed Maintenance

This phase combines the maintenance tests of phases 1.1 and 2.1 to ensure all baseline relations are maintained. The same procedures as outlined above for maintenance testing should be followed.

Phase 3.2: Testing for Combinatorial Entailment (Derived Intraverbal)

For this phase, the sample stimulus will either be the auditory name of an “animal” or the auditory sound one of the “animals” makes. Follow the procedures in Phase 1.2, using the verbal instructions, “What does [name] say?” or “What says [sound]?” as appropriate.

If the student passes Phase 3.2 (as designated by the program, this will be when the student achieves seven out of eight consecutive correct responses), go on to table-top training/generalization testing. If the student does *not* pass Phase 3.2, go on to Phase 3.3.

Phase 3.3: Training Intraverbal Relations

Using the same procedures as in Phase 1.1, use the verbal instructions, “What does [name] say?” or “What says [sound]?” as appropriate.

When the student passes Phase 3.3 (as designated by the program, this will be when the student achieves five out of six consecutive correct responses), return to Phase 1 with a new stimulus set. If the student does not pass Phase 3.3, contact Siri.

Procedure—Table-top training/generalization testing

Follow the same training and testing procedures as above, using the stimulus sets for table-top training and the following instructions:

Phase 1.1: Training in Baseline Relations—Listener Responding (Name)

Use the DGI format for teaching/correcting as above, laying out the comparison stimuli on the table. Demonstrate first by stating, “[name] is what this one is called” and pointing to the correct comparison. For independent trials, ask, “Which one is called [name]?”.

Phase 1.2: Testing for Mutual Entailment (Derived Tact)

Conduct 6 test trials. Hold up a sample stimulus, and ask, “What’s this called?”. Do not provide any specific feedback on trials.

Phase 2.1: Training in Baseline Relations—Listener Responding (Sound)

Use the DGI format for teaching/correcting as above, laying out the comparison stimuli on the table. Demonstrate first by stating, “[sound] is the sound this one says” and pointing to the correct comparison. For independent trials, ask, “Which one says [sound]?” and lay out the comparison stimuli.

Phase 2.2: Testing for Mutual Entailment (Derived Tact (sound))

Conduct 6 test trials. Hold up a sample stimulus, and ask, “What does this say?”. Do not provide any specific feedback on trials.

Phase 3.1: Mixed Maintenance Test

Check for maintenance of baseline relations, randomly alternating between laying out comparison stimuli and asking “Which one says [sound]?” or “Which one is called [name]?”.

Phase 3.2: Testing for Combinatorial Entailment (Derived Intraverbal)

Conduct 8 test trials. Without pictures present, randomly alternate between asking “What does [name] say?” or “What says [sound]?”. Do not provide any specific feedback on trials.

Phase 3.3: Training Intraverbal Relations

Randomly alternate between asking (a) “What does [name] say?” or (b) “What says [sound]?”. Use DGI procedures as above for correcting responses. Demonstrate by stating (a) “[name] says [sound]” or (b) “[sound] is the sound [name] makes”.

Appendix D

Program: Derived Intraverbals (Coordination)

1. Listener Responding/Derived Tact: Name

1.1. Train A→B (LR: [name] is what this one is called/Which one is called [name]?): *criteria=6 consecutive correct across exemplars*

1.2. Test B→A (T:What is this one [pic] called?): *criteria= 5/6 correct across exemplars*

Date	Train A1→B1						Train A2→B2						Test B1→A1		Test B2→A2	
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

2. Listener Responding/Derived Tact: Sound

2.1. Train C→B (LR: [sound] is the sound this one says/Which one says [sound]?): *criteria=6 consecutive correct across exemplars*

2.2. Test B→C (T:What does this one [pic] say?): *criteria= 5/6 correct across exemplars (go to step 2)*

Date	Train C1→B1						Train C2→B2						Test B1→C1		Test B2→C2	
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

3. Combinatorial Entailment: Derived Intraverbals Name/Sound

3.1. Check mixed maintenance A→B, C→B : *criteria=8/8 consecutive correct across exemplars*

3.2. Test A→C (What does [name] say?) and C→A (What says [sound]?): *criteria= 7/8 correct across exemplars Remediation:Train C→A (then return to 1.1 with new stimulus set)*

Date	Maint A1→B1				Maint C1→B1				Maint A2→B2				Maint C2→B2				Test AC1	Test AC2	Test CA1	Test CA2
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Data Collection Instructions: Fill in targets. Circle correct/incorrect each trial presentation; score right to left and top to bottom, drop down a row after an error is made and restart your count towards 6 consecutive correct responses using as many rows as needed. Do not score trials within a correction procedure. Fill in date for each teaching session on first row used for session. End session after either 6 cumulative errors, 25 trials total, reaching pass criteria for that step, or based on student motivation. At end of each teaching session highlight trials indicating pass criteria (if reached).

Protocol:

Arbitrary relational responding same/different—ToF (unidirectional)

Training outline:

Train “B” likes the same as “A”, and “B” likes different from “C”.

Identify what food A/C likes.

Ask what food B likes.

TARPA Program:

DIFFERENT

STAGE 2

Level 5

To quit the stimulus set, select Quit.

To end the program, press the home button on the iPad.

Procedure:

As warranted for an introduction, talk about what foods your student likes. Then, tell the student, “We are going to learn some more about the funny animals who like different things to eat. We’re going to learn that some animals like the *same* foods as each other, and some animals like foods that are *different*.” or any similar introduction to the activity context.

Teacher demo (D)

- Touch each picture box to display the animal (touch all 4; only 3 will show animals), then touch color/food cards to show those. Make sure student can tact all animals and foods.
- The “B” stimulus (random placement) is highlighted by the program.
- Touch “B”. Either SAME or DIFFERENT will be highlighted. (“A” will highlight once the SAME cue is selected, “C” will highlight once the DIFFERENT cue is selected)
- Say, and touch each relevant box, “[B] likes the SAME/DIFFERENT food as [A]/[C]”
- Repeat so that both $B=A$ and $B \neq C$ are demonstrated

Training (Tr)

- Select the training mode
- The [B] stimulus will stay highlighted, while the SAME or DIFFERENT button is highlighted by the program.
- Have the student say and select the appropriate stimulus as well as the cue “[B] is the SAME/DIFFERENT as...”
- Student response is to say and touch [A]/[C]. If necessary, block responding until the student vocally says the full sentence.
- Correct responses result in reinforcement playing. Incorrect responses result in nothing.

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- For incorrect responses, repeat the SD with correct answer vocally and then have the student repeat the SD vocally and respond by selecting the correct animal.
- Training is passed when student gets 10 consecutive correct answers. A progress bar indicates consecutive correct answers and will reset with errors.

ToF Testing

- Select the testing mode (“**ME**”)
- The [A/C] highlight appears.
- Ask the student to select what food “A/C” likes (there is no correct answer, whatever he wants to select is fine) and drag the relevant food card next to the A/C stimulus
- [B] is highlighted. Ask "what does [B] like?". Student drags relevant color card next to A/C.

4) Repeat

Select **Demo** to bring up a new stimulus set (A/B/C and foods) and repeat for a total of 6 ToF tests per session.

Tracking and reviewing data:

Manually note whether the test response was correct or incorrect; before ending the program whether to take a break or at the end of the session, review the data after the all done screen to check your entries.

Training:

Relational Tact training

ToF training

ToF training with multiple food stimuli and instructor prompts to tact the relation before selecting the food item, and the provision for correcting.
e.g.

A=B/=C

random highlight: A : likes chips (dragged into place)

B is highlighted

- instructor prompt: do A and B like same or different? (same)
- instructor: so what food does B like? (error made)
- instructor drags incorrect food back into place and prompts: do A and B like same or different? [same] which food is same as chips (point to chips next to A)? (correct response made)

new food set

- stay with relation that error was made on: same (A)
- until correct response made with new food set
- then new random highlight of either A or C and new food set etc. until 5 consecutive correct

then new animal set (back to demo)

- continue until first 5 trials correct with multiple food sets
- then test without relational tact training with new animal sets

Arbitrary same/different relational responding: MTS training/derived Trained Relation ToF Topographical Generalization Test

Procedure:

Talk about what foods your student likes. Then, tell the student, “We are going to learn some more about [the crazy animals—or you can use people, pets, etc., whatever is motivating for the student]. Just like you, these [animals] like different things to eat. We’re going to learn that some animals like the *same* foods as the one you’ll see, and some animals like foods that are *different*.”

Materials

Whiteboard or other area to write out relations and food options.

Preparation for each set: Write down three animals or other characters on the board with blank lines next to them, and write down two foods separately.

E.g.:

lion _____

tiger _____

bear _____

candy

ice cream

DIFFERENT:

B→A Same

Write out: “[B] likes the *same* food as [A]”.

B→C Different

Write out: “[B] likes *different* food than [C]”.

Trained/ToF DERIVED DIFFERENT TEST (C→B)

Say: “[C] likes [food I]” and write the food next to [C] on the board.

Ask: “What does [B] like?” Student may either vocally respond, or write down next to [B] the food.

ME/ToF: B→C

SAME:

B→C Different

Write out: “[B] likes *different* food than [C]”.

B→A Same

Write out: “[B] likes the *same* food as [A]”.

Trained/ToF DERIVED SAME TEST (A→B)

Say: “[A] likes [food I]” and write the food next to [A] on the board.

Ask: “What does [B] like?” Student may either vocally respond, or write down next to [B] the food.

ME/ToF: B→C

Select a new stimulus set (A/B/C and foods) and repeat for a total of 6 Trained/ToF tests with a total of 3 DIFFERENT and 3 SAME tests. Randomly alternate SAME/ DIFFERENT.

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Topographical Generalization Test: Trained/ME Relation ToF Student:

Date/ Sessio n #	Set 1 S D	Set 2 S D	Set 3 S D	Set 4 S D	Set 5 S D	Set 6 S D	Total
1							

Set 1

A:

B:

C:

food1:

food2:

Set 2

A:

B:

C:

food1:

food2:

Set 3

A:

B:

C:

food1:

food2:

Set 4

A:

B:

C:

food1:

food2:

Set 5

A:

B:

C:

food1:

food2:

Set 6

A:

B:

C:

food1:

food2:

Class Inclusion/Hierarchy: Nonarbitrary Relations Tabletop Screening Protocols

Screening should be conducted as a teaching type session, with interspersal of non-targeted questions as needed to maintain motivation, and reinforcement as appropriate for the student's plans/needs.

Simple tacting

Select one exemplar of each stimulus item. Shuffle all stimulus cards together. For each stimulus to be used, hold up the card, or point to the card on the table, and ask "What is this?"

Score first trial for each stimulus item.

Provide praise/reinforcement for correct responses.

If any items are not correctly tacted, provide corrective feedback, and repeat the SD. Set aside.

Return to any incorrectly tacted items at the end of the session. If correctly tacted, repeat tact trial in next session; if retained then keep in stimulus set, but if not retained set aside.

Student must get 100% correct responding on all stimuli to be used to continue with those stimuli.

Yes/No tacting

Select one exemplar of each stimulus item. Shuffle all stimulus cards together.

Randomly select 20 stimulus items to be used.

Randomize presentation of "yes" and "no" tact trials.

For each trial, hold up or point to the card on the table, and ask "Is this a [stimulus name]" or "Is this a [not stimulus name, but other name within category]". For example, if the stimulus is a cat, ask either, "Is this a cat?" or "Is this a dog?"

Provide praise/reinforcement for correct responses.

Provide corrective feedback for incorrect responses.

Terminate following 10 "yes" and 10 "no" trial types.

Student must get 19/20 responses correct to continue.

Category tacting

Prior to starting, ensure the student can respond to the contextual cue of "category". Select one exemplar of each stimulus item. Shuffle all stimulus cards together. Tell the student, "now I am going to ask you to tell me the category each of these belongs to. For example, this [hold up a stimulus item] is a type of [name the category], so if I ask you 'What category is this?' you would answer [category]. Let's try it— 'What category is this?'. If the student does not respond correctly, terminate screening.

For each stimulus to be used, hold up the card, or point to the card on the table, and ask "What category is this?"

Score first trial for each stimulus item.

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Provide praise/reinforcement for correct responses.

If any category/items are not correctly tacted, provide corrective feedback, and repeat the SD. Set aside.

Return to any incorrectly tacted items at the end of the session. If correctly tacted, repeat tact trial in next session; if retained then keep in stimulus set, but if not retained set aside.

Student must get 100% correct responding on all stimuli to be used to continue with those stimuli.

Quantity tacting

Randomize presentation of quantities of stimuli from 1-10, with different stimuli used for each trial.

Set out a quantity of stimuli. Ask the student, "How many [stimuli] are there?"

Provide praise/reinforcement for correct responses.

If any quantity is not correctly tacted, provide corrective feedback, and repeat the SD.

Return to any incorrectly tacted quantity with new stimuli at the end of the session.

If correctly tacted, repeat tact trial in next session; if retained then continue, but if not, terminate screening.

Student must be able to tact quantities to 10 with first trial correct responding in order to continue.

Nonarbitrary Relational Tacting: More/Less

Using the stimulus selection cue cards to randomize selection, set out two sets of stimuli.

Randomize presentation of four trial types:

Are there more [stimuli 1] or [stimuli 2]?

Are there less [stimuli 1] or [stimuli 2]?

Are there more [stimuli 2] or [stimuli 1]?

Are there less [stimuli 2] or [stimuli 1]?

Provide praise/reinforcement for correct responses.

If any relation is not correctly tacted, provide corrective feedback, and repeat the SD.

Terminate following 20 total trial presentations (5 per type)

Student must get 19/20 responses correct to continue.

Class Inclusion/Hierarchy: Nonarbitrary Relations Assessment and Training Protocol Study 9.1

Materials (see attached):

- pictures of animals, fruits, vehicles, clothing
- cue card sets for stimulus selection
- cue card sets for mixing trials: quantity, nonarbitrary more/less, mastered FFC, class inclusion (80 trials, ratio of 3:1 mastered to class inclusion)
- training presentation sheet with one large circle containing two smaller circles (laminated)
- data sheets
- reinforcement systems as individualized per student

Prerequisite Skills:

Student must be able to (see screening protocol):

- demonstrate combinatorial entailment in a frame of coordination with familiar stimuli (TARPA SAME AV2i with real life stimulus sets 1 and 2)
- tact all pictures of items
- tact using yes/no
- tact the category of all items
- tact the quantity of items from 1-10
- tact the nonarbitrary relation of two sets of items as being “more” or “less”

Baseline and Generalization Assessment:

1. Shuffle each set of cue cards (stimulus selection, trial mixing).
2. Have the student select a card for stimuli; lay out stimuli accordingly (e.g., 2 cats, 4 horses).
3. Select a card for the trial.
4. Present trial SD.
5. Provide nonspecific praise/noncontingent reinforcement for each trial (e.g., “you’re working really hard!” “I like how you’re paying attention”); reinforce participation on schedule as determined by student behavior plan or teacher recommendation.
6. Record responses to class inclusion questions per category.
7. If non-class inclusion questions are answered incorrectly, make note; all non-class inclusion questions should be mastered as assessed during screening.
8. Terminate session after 20 class inclusion questions in total.

Appendix D

Intervention:

Separate out animal pictures and stimulus selection cards for use during intervention; only animals will be used. Shuffle each set of cue cards (stimulus selection, trial mixing). Place the training presentation sheet in front of the student. Have the student select a card for stimuli; lay out stimuli accordingly (e.g., 2 cats, 4 horses) on the training presentation sheet. Write out the names of the stimuli (e.g., cats, horses) underneath each of the relevant smaller circles. The category name (animals) should be written above the larger circle.

1. Select a card for the trial.
2. Present trial SD.
3. Provide specific praise and feedback for all correct responses (e.g., "That's right! There are 4 horses," "That's right, there are more animals than cats!")
4. For incorrect responses to "more" class inclusion questions, provide corrective feedback as follows:
5. State that "a [animal1] is a type of animal, and [animal2] is a type of animal" (e.g., "a cat is an animal and a horse is an animal"), "since these are all animals, there are more animals than [animal1/2]."
6. Repeat the class inclusion SD
7. Provide specific praise and reinforcement for correct responding.
8. Select a new set of stimuli and repeat the same trial type ("more" class inclusion) until correct first trial response with new stimulus set.
9. For incorrect responses to "less" class inclusion questions, provide corrective feedback as follows:
10. State that "a [animal1/2] is a type of animal, but not all the animals are [animal1/2]" (e.g., "a cat is an animal but not all the animals are cats"), "since these are not all [animal1/2], there are less [animal1/2] than animals."
11. Repeat the class inclusion SD
12. Provide specific praise and reinforcement for correct responding.
13. Select a new set of stimuli and repeat the same trial type ("less" class inclusion) until correct first trial response with new stimulus set.

Record first-trial (i.e first with stimulus set) responses to class inclusion questions per category.

If non-class inclusion questions are answered incorrectly, make note; all non-class inclusion questions should be mastered as assessed during screening.

Terminate session after 20 class inclusion questions in total.

Class Inclusion/Hierarchy: Nonarbitrary Relations Assessment and Training Protocol Study 9.2 & 9.3

Materials (see attached):

- pictures of animals, fruits, vehicles, clothing
- cue card sets for stimulus selection
- cue card sets for mixing trials: quantity, nonarbitrary more/less, mastered FFC, class inclusion (maximum of 40 trials, ratio of 1:1 mastered to class inclusion)
- training boxes with one large box containing two smaller boxes (clear plastic), dry erase marker
- data sheets
- reinforcement systems as individualized per student

Prerequisite Skills:

Student must be able to (see screening protocol):

- demonstrate combinatorial entailment in a frame of coordination with familiar stimuli (TARPA SAME AV2i with real life stimulus sets 1 and 2)
- tact all pictures of items
- tact using yes/no
- tact the category of all items
- tact the quantity of items from 1-10
- tact the nonarbitrary relation of two sets of items as being “more” or “less”

Baseline and Generalization Assessment:

1. Shuffle each set of cue cards (4 sets for stimulus selection, separated by category; 1 set for trial selection consisting of 8 class inclusion trials [one of each trial type] + 8 interspersal trials).
2. Have the student select a card for stimuli; lay out stimuli accordingly (e.g., 2 cats, 4 horses).
3. Select a card for the trial type.
4. Present trial SD.
5. Provide nonspecific praise/noncontingent reinforcement for each trial (e.g., “you’re working really hard!” “I like how you’re paying attention”); reinforce participation on schedule as determined by student behavior plan or teacher recommendation.
6. Record responses to class inclusion questions per trial type.
7. If non-class inclusion questions are answered incorrectly, make note; all non-class inclusion questions should be mastered as assessed during screening.
8. Remove the stimulus sets, rotate to a new category for stimulus selection, and repeat.
9. Terminate session after 8 class inclusion questions in total.

Intervention Phase I—Errorless Teaching:

Separate out animal pictures and stimulus selection cards for use during intervention; only animals will be used. For trial cards, use one set, containing one of each class inclusion trial type and an equal number of interspersal questions of varying trial types. Shuffle each set of cue cards (stimulus selection, trial mixing).

Place the training boxes in front of the student—one large clear plastic box for the category and two clear smaller plastic boxes for the stimulus types. State and point to the boxes: “This big box is for the category. What category do these belong to? [point to all the stimulus pictures]” [Student should say “animals”] “That’s right. Let’s write the category on the box.” [Teacher or student (depending on student preference) should write “animals” on the box]. “These two smaller boxes are for the different animals. The small boxes will go inside the animal category box.”

Have the student select a card for stimuli; teacher should select a trial type card for the trial. The teacher or student (depending on student preference) should write the names of the stimuli on each of the boxes (e.g. pig on one box and dog on another box), using dry erase marker.

1. Tell the student to put the stimuli in the appropriate boxes, stating the names of the stimuli, e.g. “Put the [stimulus 1/2] in the small [stimulus 1/2] box, and the [stimulus 1/2] in the small [stimulus 1/2] box”. Once the stimuli are in the appropriate boxes, state “Great. [[stimulus 1/2]] and [stimulus 1/2] are types of animals, they belong to the animal category, so they all go inside the big animal category box.” Student should place both boxes inside the larger box.
2. In the same order as the trial type card, tell the student to identify the stimulus box and the category box, e.g. if the trial type is more [stimulus2] or more [category], then state “show me the [stimulus2] box”. Once the student correctly picks up or points to the stimulus2 box, state “show me the animal category box”.
3. If the student makes an error in selecting the animal box (e.g. picks up the other stimulus box), demonstrate the correct response by picking up the animal box and stating “These all belong to the animal category. This is the animal category box.” Restate “show me the animal category box,” and repeat until student is correct.
4. Present trial SD while picking up each of the relevant boxes as you present the SD.
5. Provide specific praise and feedback for all correct responses, picking up the boxes (e.g., “That’s right! There are 4 horses [pick up box],” “That’s right, there are more animals [pick up box] than dogs [pick up box]!/ there are less dogs than animals!”)
6. For incorrect responses to “more” class inclusion questions, provide corrective feedback as follows:
 - Repeat the requirement to identify the stimulus and animal boxes, as in step 3/4.
 - State, while picking up the boxes, “That’s right. [stimulus 1/2] and [stimulus 1/2] are types of animals, so they all go inside the big animal category box.

They all belong to the animal category but only these are [stimulus 1/2], so there are more animals in the animal category box than there are [stimulus 1/2] in the [stimulus 1/2] box.

- Repeat the trial SD as in step 5.
 - Provide specific praise and reinforcement for correct responding.
 - Select a new set of stimuli and repeat the same trial type (specific type of “more” class inclusion) until correct first trial response with new stimulus set; intersperse a distracter trial, and repeat until there are a total of **three consecutive correct** first trial responses with a new stimulus set.
7. For incorrect responses to “less” class inclusion questions, provide corrective feedback as follows:
 - **Repeat the requirement** to identify the stimulus and animal boxes, as in step 3/4.
 - State, **while picking up the boxes**, “That’s right. [stimulus 1/2] and [stimulus 1/2] are types of animals, so they all go inside the big animal category box. They all belong to the animal category but only these are [stimulus 1/2], so there are less [stimulus 1/2] in the [stimulus 1/2] box than there are animals in the animal category box.”
 - Repeat the trial SD as in step 5.
 - Provide specific praise and reinforcement for correct responding.
 - Select a new set of stimuli and repeat the same trial type (specific type of “less” class inclusion) until correct first trial response with new stimulus set; intersperse a distracter trial, and repeat until there are a total of **three consecutive correct** first trial responses with a new stimulus set.
 8. Record first-trial (i.e first with stimulus set) responses to class inclusion questions per trial type; do not record responses during correction.
 9. If non-class inclusion questions are answered incorrectly, make note; all non-class inclusion questions should be mastered as assessed during screening.
 10. Terminate session after a correct response has been given on each of the 8 class inclusion questions.

Move to next phase once student is 100% correct in selecting appropriate boxes and achieves 8/8 first trial correct with class inclusion questions.

Intervention Phase 2:

Use the same stimulus type and trial type card setup as previously, but use 3 sets of trial cards (8, 8, and 4 class inclusion questions, one of each type per set, mixed with equal numbers of interspersal questions). In this phase, verbal reference to the size of the boxes and the pre-trial requirement to identify the boxes by type/category are eliminated.

1. Have the student select a card for stimuli; teacher should select a trial type card for the trial. The teacher or student (depending on student preference) should **write** the names of the stimuli on each of the boxes (e.g. pig on one box and dog on another box), using dry erase marker.
2. Tell the student to put the stimuli in the appropriate boxes, stating the names of the stimuli, e.g. **“Put the pigs in the pig box, and the dogs in the dog box”**. Once the stimuli are in the appropriate boxes, state **“Now put all of them inside the animal category box.”** Student should place both boxes inside the larger box.
3. Present trial SD (do not pick up the boxes).
4. Provide specific praise and feedback for all correct responses, referencing and picking up the boxes and stating that they all belong to the animal category, but only the stimulus type is the stimulus, for class inclusion trials, but without the verbal reference to the boxes (e.g., **“That’s right! There are 4 horses [pick up box],”** **“That’s right, there are more animals [pick up box] than dogs [pick up box]!/ there are less dogs than animals!”**)
5. For incorrect responses to “more” class inclusion questions, provide corrective feedback as follows:
 - Present the SD to identify the stimulus and animal boxes, as in step 3/4 of the errorless teaching phase.
 - State, **while picking up the boxes,** **“they all belong to the animal category but only these are [stimulus 1/2], so there are more animals than there are [stimulus 1/2].”**
 - Repeat the trial SD (without picking up the boxes).
 - Provide specific praise and reinforcement for correct responding.
 - Select a new set of stimuli and repeat the same trial type (specific type of “more” class inclusion) until correct first trial response with new stimulus set; intersperse a distracter trial, and repeat until there are a total of **three consecutive correct** first trial responses with a new stimulus set.
6. For incorrect responses to “less” class inclusion questions, provide corrective feedback as follows:
 - Repeat the requirement to identify the stimulus and animal boxes, as in step 3/4 of the errorless teaching phase.
 - State, **while picking up the boxes,** **“they all belong to the animal category but only these are [stimulus 1/2], so there are less [stimulus 1/2] than there are animals”**
 - Repeat the trial SD (without picking up the boxes).
 - Provide specific praise and reinforcement for correct responding.
 - Select a new set of stimuli and repeat the same trial type (specific type of “less” class inclusion) until correct first trial response with new stimulus set;

intersperse a distracter trial, and repeat until there are a total of **three consecutive correct** first trial responses with a new stimulus set.

7. Record first-trial (i.e. first with stimulus set) responses to class inclusion questions per trial type; do not record responses during correction.
8. If non-class inclusion questions are answered incorrectly, make note; all non-class inclusion questions should be mastered as assessed during screening.
9. Terminate session after a correct response has been given on each of the 8 class inclusion questions.

Move to next phase once student achieves 8/8 first trial correct with class inclusion questions.

Generalization Phase 1: Animals

Using only the animal cards, follow the procedure as above for baseline/generalization (i.e. do not use the boxes or provide feedback).

If responses do not generalize without the boxes, return to Intervention Phase 2.

Generalization Phase 2: Novel categories

Follow the procedure as in baseline, with all categories **except animals** represented.

If responses do not generalize to novel stimuli, return to Intervention Phase 1 with a new category.