European Journal of Behavior Analysis

ISSN: 1502-1149 (Print) 2377-729X (Online) Journal homepage: http://www.tandfonline.com/loi/rejo20

Derived Relational Responding and Generative Language: Applications and Future Directions for Teaching Individuals With Autism Spectrum Disorders

Siri Ming, Laura Moran & Ian Stewart

To cite this article: Siri Ming, Laura Moran & Ian Stewart (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

To link to this article: http://dx.doi.org/10.1080/15021149.2014.11434722

Published online: 10 Jun 2015.

EUROPEAN JOURNAL OF BEHAVIOR ANALYSIS 2014, **15**, 199–224 NUMBER 2 (WINTER 2014)

Derived Relational Responding and Generative Language: Applications and Future Directions for Teaching Individuals With Autism Spectrum Disorders

Siri Ming, Laura Moran, and Ian Stewart
National University of Ireland, Galway

While many individuals with autism spectrum disorders (ASD) develop a flexible, generative language repertoire following intensive early intervention, many others continue to require intensive teaching and exhibit language repertoires that could be characterized as rigid or rote. Research in the area of derived stimulus relations shows promise for developing teaching procedures for students with ASD that focus on remediating these deficits and establishing generative verbal behavior. We provide an explanation of the theoretical background of derived stimulus relations research, with an emphasis on Relational Frame Theory, and review studies that (i) demonstrate the establishment of derived relational responding when such skills are absent, and (ii) use existing derived relational responding skills to teach educationally relevant skills to individuals with ASD or other developmental disabilities. Based on this review, we give a number of recommendations for teaching and curricular sequencing principles, assessment strategies, and areas for future research.

Key words: relational frame theory, equivalence, derived relational responding, autism, language intervention

Impairments in communication are core diagnostic features of autism spectrum disorders (ASD). As such, 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). 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; Lovaas, 1987; Perry, Cohen, & DeCarlo, 1995), 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—the ability to produce and understand sentences never heard or said before (Greer & Ross, 2008; Malott, 2003).

Correspondence concerning this article should be addressed to Siri Ming, School of Psychology, National University of Ireland, Galway, Ireland, email: siri@siriming.com.

This suggests that linguistic generativity is critically important but that behavior analysis lacks an effective understanding of this phenomenon. Furthermore, a relatively recent quote from Richard Malott in which he refers to linguistic generativity or, as he calls it, productivity, as the "greatest intellectual challenge to the field of behavior analysis" (2003, p. 11) would seem to support both these conclusions. However, while the first conclusion is still as true today as ever, there is now hope that behavior analytic science has begun to gain a better understanding of generative language. Developments in the area of derived stimulus relations research seem promising in this respect. 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 paper 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.

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 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 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 in ability to show derived equivalence relations. In typically developing humans, derived equivalence relations develop in parallel with language ability (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). A wealth of empirical evidence has accumulated based on the account provided by 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, we will largely use this approach as the theoretical background to our review.

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*. 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, Gifford, Wilson, Barnes-Holmes & Healy, 2001; Reese, 1968; Stewart & McElwee, 2009). However, RFT posits a further type of generalized relational responding that can be learned in which the relational response is determined by contextual cues independent of the properties of the related objects. For example, if I am told that X is the same as Y and Y is the same as Z, then I can derive that Y is the same as X, Z is the same as Y, X is the same as Z and Z is the same as X. In this case, the pattern of derived relational responding is not based on the actual properties of the letters, but on the contextual cue 'same as', which was established to function as such in the course of my learning history as we will describe further below. RFT theorists argue that the reinforcement history that has led to this type of sameness (or *coordination*) relational responding is what underlies an organism's ability to respond in accordance with a pattern of stimulus equivalence. From the RFT perspective, however, sameness is only one type of derived relational pattern. Over the last two decades, RFT researchers have provided empirical evidence for a variety of other 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, Strand, & Friman, 2004), *analogy* (e.g., Persicke, Tarbox, Ranick & St. Clair, 2012; Stewart, Barnes-Holmes, Roche & Smeets, 2004), *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 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., O'Hora, Barnes-Holmes, Roche, & Smeets, 2004; Stewart, et al., 2004; Wulfert & Hayes, 1988). 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.

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, Hayes & Capurro (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→B) and then being able to respond in the other direction (B→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→B and C→B, then A→C and C→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.

Thus, from the current perspective, derived relational responding, with its properties of mutual and combinatorial entailment and transformation of functions is a key process involved in learning generative language. The purpose of this review is to examine two primary areas of research: a) studies that have established derived relational responding skills 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 to which we will also return throughout this review.

We believe that RFT provides a coherent and thorough framework for understanding derived relational responding and how it relates to generative language and accordingly in our introduction we have provided a brief overview of the RFT conception of derived relational responding as relational framing that will allow theoretical direction for our 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 we recognize the value of their work 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; ; Luciano, Rodríguez & Mañas, 2009; Miguel, Yang, Finn & Ahearn, 2009). Most importantly we will highlight the benefits of incorporating relational responding into behavioral educational curricula for individuals with developmental disabilities.

Derived Relational Responding: Two Types of Studies

We have 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 we will review studies 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 have the ability to derive 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 skills is critical in order to establish generative verbal behavior. We will therefore review 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 ability, such as responding in accordance with stimulus equivalence/frames of coordination, which has been acquired through exposure to natural socio-verbal 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 repertories 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 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 we will review below.

With respect to both of these areas of need—establishing derived relational responding skills 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. We will address this need for functional assessment of existing derived relational responding skills in our concluding discussion of this review.

Establishing Derived Relational Responding Skills

We will first examine the growing body of research showing the establishment of derived relational responding skills. 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 we will discuss 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, Barnes-Holmes & Barnes-Holmes, 2005), comparison (Barnes-Holmes, Y., Barnes-Holmes, D., Smeets, Strand, & Friman, 2004; Berens & Hayes, 2007; Gorham, Barnes Holmes, Barnes-Holmes & Berens, 2009; Murphy & D. Barnes-Holmes, 2010), opposition (Barnes-Holmes, Y., Barnes-Holmes, D., & Smeets, 2004), and *perspective taking* (Rehfeldt, Dillen, Ziomek & Kowalchuk, 2007; Weil et al., 2011). In what follows, we review empirical examples of the training of these frames.

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 skills, since these skills appear 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 bidirectional 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- 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). 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 [Michael, 1988, Skinner, 1957]) 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 we have considered a number of RFT-based studies that have used MET to train coordinate relations. 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 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., Greer & Keohane, 2004; Greer, Stolfi, Chavez-Brown, & Rivera-Valdes, 2005; Horne & Lowe, 1996). 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; Fields, Arntzen, Nartey & Ellifsen, 2012; Holth & Arntzen, 1998; Horne, Hughes, & Lowe, 2006; Horne, Lowe, & Harris, 2007; Lowe, Horne, & Hughes, 2005 though see also Luciano et al., 2007, O'Connor, Rafferty, Barnes-Homes, D. & Barnes-Holmes, Y., 2011). 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, we will consider studies 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, 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, D. Barnes-Holmes, Smeets, Strand, 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, D. Barnes-Holmes, and Smeets (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 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, D. Barnes-Holmes and Smeets (2004), typically developing 4 to 6 year old children were tested and then trained for the ability 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=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 cold?"). Both children failed initial tests of this ability, 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, D. Barnes-Holmes, and Smeets (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; Downs & Smith, 2004; Flavell, 2004; Klin, Schultz, & Cohen, 2000; Perner, 1988, 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 et al. (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 ability to perform on these deictic relational responding tasks follows a similar developmental sequence to ability to perform on tests of Theory of Mind (McHugh, et al., 2004; McHugh, , Barnes-Holmes, Barnes-Holmes, Stewart, & Dymond, 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, Barnes-Holmes & Murphy, 2010).

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

We will next examine studies that have used participants' existing repertoire of derived relational responding to further other educational goals. 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 we will refer 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 & Miguel (2013) and Miguel et al. (2009) evaluated whether an appropriate pattern of conditional discrimination training 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 & 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 for their ability to mand 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 research further, Murphy and 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 skills 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 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 et al., (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 ability 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 ability 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) strongly indicates the merits of targeting skills using an RFT analysis when designing language interventions for children with ASD or developmental delay more broadly.

Conclusions and Future Directions

As outlined above, there is now a small but growing body of evidence both for using existing derived relational responding skills to quickly and efficiently teach new concepts and generate more varied responding (such as novel mands), and also for training derived relational responding skills when they are absent. As stated initially, we propose that 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 skills across a variety of relational frames) as well as procedures for teaching such skills. Regardless of the differences in theoretical orientations and debate within the field about underlying processes, all the studies reviewed here 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. We would argue 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 skills (whether naming, equivalence, or more advanced relational frames), then we argue 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. Some of the research studies that have been discussed in this article 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 (Barnes-Holmes, Y., Barnes-Holmes, D., Smeets, Strand et al., 2004; Barnes-Holmes, Y., Barnes-Holmes, D., & Smeets, 2004; Berens & Hayes, 2007; Gorham et al., 2009); (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); (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); (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).

Finally, in order to implement the above recommendations, it is first necessary to assess a student's current derived relational responding ability, 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, 2008] do reference the emergence of novel behavior as a progress marker), and we argue 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) is currently being developed for the assessment of precursor and early relational responding abilities. The TARPA is a computer based protocol that assesses a number of key forms of responding that are critical (from a derived relational responding perspective) to the development of generative behavior, including 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 comprehensive assessment of the prerequisite skills to relational responding as well as assessment of relational responding abilities at the level of equivalence.

Rehfeldt (2011) highlighted 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 for understanding spoken language. The TARPA, which is designed to assess relational responding across modalities, could be an important basic and applied tool in the future study of this particular area. In addition, the same sequence of testing inherent in the TARPA could be carried out in table-top formats in order to assess topographical responding (e.g., spoken words, signs, written responses, spelling) rather than selection-based responding, and further research in this area is clearly needed. A move away from the match-to-sample formats frequently used in research into relational responding may 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, the TARPA is currently being developed to allow assessment and training of frames other than equivalence (e.g., distinction, opposition, comparison) which will also advance research in this area. Indeed, Rehfeldt (2011) 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 research presented in this paper would suggest that behavior analysis is primed for this and that in fact it is already happening (e.g., Gorham et al., 2009; Murphy & Barnes-Holmes, 2010).

There is clearly much research to be done to determine the most effective and efficient means of establishing derived relational responding skills, the sequencing of the component skills necessary for derived relational responding, and the sequencing of different relational frames. In addition, Rehfeldt (2011) outlined recommendations for future research into the transportability, generalization and maintenance of relational responding interventions. Nonetheless, what has been accomplished so far provides important additional direction for behaviorally-based programs for individuals with autism and other language delays. Traditionally, we have measured progress through the acquisition of content—for example, numbers of tacts and mands, or the number of nouns, verbs, and prepositions, and so on. However, working from the perspective of the derived relational responding literature, targeting a small number of processes (bidirectional or mutually entailed responding, combinatorially entailed responding, transformation of function) within different patterns of derived relational responding (same, different, comparison and so on) allows complex verbal behavior to be established systematically and efficiently, and allows for progress to be systematically assessed not just in terms of content, but also in terms of critical language learning processes. Undoubtedly this is an exciting prospect for behavioral intervention.

References

Barnes, D. (1994). Stimulus equivalence and relational frame theory. *The Psychological Record, 44*, 91–124. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Barnes, D., Hegarty, N. &, Smeets, P. (1997). Relating equivalence relations to equivalence relations: A relational framing model of complex human functioning. *The Analysis of Verbal Behavior, 14*, 1–27. Retrieved from http://www.abainternational.org/journals/the-analysis-of-verbal-behavior.aspx.

Barnes-Holmes, D., Barnes-Holmes, Y., & Cullinan, V. (2000). Relational frame theory and Skinner's verbal behavior: A possible synthesis. *The Behavior Analyst*, *23*, 69–84. Retrieved from http://www.abainternational.org/journals/the-behavior-analyst.aspx.

Barnes-Holmes, Y., Barnes-Holmes, D., Roche, B., & Smeets, P. M. (2001a). Exemplar training and a derived transformation of function in accordance with symmetry. *The Psychological Record*, *51*, 287–308. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Barnes-Holmes, Y., Barnes-Holmes, D., Roche, B., & Smeets, P. M. (2001b). Exemplar training and a derived transformation of function in accordance with symmetry: II. *The Psychological Record*, *51*, 589–603. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Barnes-Holmes, Y., Barnes-Holmes, D., & Smeets, P. M. (2004). Establishing relational responding in accordance with opposite as generalized operant behavior in young children. *International Journal of Psychology and Psychological Therapy, 4*, 559–586. Retrieved from http://www.ijpsy.com/

Barnes-Holmes, Y., Barnes-Holmes, D., Smeets, P. M., Strand, P., & Friman, P. (2004). Establishing relational responding in accordance with more-than and less-than as generalized operant behavior in young children. *International Journal of Psychology and Psychological Therapy, 4*, 531–558. Retrieved from http://www.ijpsy.com/.

Baron-Cohen, S. (2001). Theory of mind in normal development and autism. *Prisme, 34*, 174–183. Retrieved from http://ejournal.narotama.ac.id/files/Theory%20of%20mind%20in%20normal%20development.pdf

Baron-Cohen, S. (2005). Autism and the origins of social neuroscience. In A. Easton & N. Emery (Eds.), *The cognitive neuroscience of social behaviour* (pp. 239–255). New York, NY: Psychology Press.

Berens, N. M., & Hayes, S. C. (2007). Arbitrarily applicable comparative relations: evidence for a relational operant. *Journal of Applied Behavior Analysis*, *40*, 45. doi:10.1901/jaba.2007.7-06

Butter, E. M., Mulick, J. A., & Metz, B. (2006). Eight case reports of learning recovery in children with pervasive developmental disorders after early intervention. *Behavioral Interventions*, *21*, 227–243. doi:10.1002/bin.225

Carpentier, F., Smeets, P. M., & Barnes-Holmes, D. (2002). Matching functionally same relations: Implications for equivalence-equivalence as a model for analogical reasoning. *The Psychological Record*, *52*, 351–370. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Carpentier, F., Smeets, P. M., & Barnes-Holmes, D. (2003). Equivalence-equivalence as a model of analogy: Further analyses. *The Psychological Record*, *53*, 349–372. Retrieved from http://opensiuc.lib.siu.edu/tpr/vol53/iss3/2/.

Gilic, L., & Greer, R. D. (2011). Establishing naming in typically developing two-year-old children as a function of multiple exemplar speaker and listener experiences. T*he Analysis of Verbal Behavior*, *27*, 157–177. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3139556/.

Cowley, B. J., Green. G., & Braunling-McMorrow, D. (1992). Using stimulus equivalence procedures to teach name-face matching to adults with brain injuries. *Journal of Applied Behavior Analysis, 25*, 461–475. doi:10.1901/jaba.1992.25-461

De Rose, J., De Souza, D. G., & Hanna, E. S. (1996). Teaching reading and spelling: Exclusion and stimulus equivalence. *Journal of Applied Behavior Analysis*, *29*, 451–69. doi:10.1901/jaba.1996.29-451

Devany, J. M., Hayes, S. C., & Nelson, R. O. (1986). Equivalence class formation in language-able and language-disabled children. *Journal of the Experimental Analysis of Behavior, 46*, 243-57. doi:10.1901/jeab.1986.46–243

Dickins, D. W., Singh, K. D., Roberts, N., Burns, P., Downes, J.J., Jimmieson, P., & Bentall, R.P. (2001). An fMRI study of stimulus equivalence. *NeuroReport, 12*, 2–7. doi: 10.1097/00001756-200102120-00043.

Dougher, M. J., Augustson, E., Markham, M. R., Greenway, D. E., & Wulfert, E. (1994). The transfer of respondent eliciting and extinction functions through stimulus equivalence classes. *Journal of the Experimental Analysis of Behavior*, *62*, 331–351. doi:10.1901/jeab.1994.62-331

Downs, A., & Smith, T. (2004). Emotional understanding, cooperation, and social behavior in high-functioning children with autism. *Journal of Autism and Developmental Disorders*, *34*, 625–635. doi:10.1007/s10803-004-5284-0

Dugdale, N., & Lowe, C. F. (2000). Testing for symmetry in the conditional discriminations of language-trained chimpanzees. *Journal of the Experimental Analysis of Behavior, 73*, 5–22. doi:10.1901/jeab.2000.73-5

Dymond, S., & Barnes, D. (1995). A transformation of self-discrimination response functions in accordance with the arbitrarily applicable relations of sameness, more than, and less than. *Journal of the Experimental Analysis of Behavior*, *64*, 163–184. doi:10.1901/jeab.1995.64-163

Dymond, S., & Roche, B. (2013). *Advances in relational frame theory: Research & application*. New York, NY: New Harbinger.

Eikeseth, S., & Smith, T. (1992). The development of functional and equivalence classes in high-functioning autistic children: The role of naming. *Journal of the Experimental Analysis of Behavior, 58*, 123–33. doi:10.1901/jeab.1992.58-123

Fields, L., Arntzen, E., Nartey, R. K., & Eilifsen, C. (2012). Effects of a meaningful, a discriminative, and a meaningless stimulus on equivalence class formation. *Journal of the Experimental Analysis of Behavior*, *97*, 163–81. doi:10.1901/jeab.2012.97-163

Fields, L., Verhave, T., & Fath, S. (1984). Stimulus equivalence and transitive associations: A methodological analysis. *Journal of the Experimental Analysis of Behavior*, *42*, 143–157. doi:10.1901/jeab.1984.42-143

Fiorile, C. A., & Greer, R. D. (2007). The induction of naming in children with no prior tact responses as a function of multiple exemplar histories of instruction. *The Analysis of Verbal Behavior*, *23*, 71–87. Retrieved from http://www.abainternational.org/journals/the-analysis-of-verbal-behavior.aspx.

Flavell, J. H. (2004). Theory-of-mind development: Retrospect and prospect. *Merrill-Palmer Quarterly*, *50*, 274–290. doi:10.1353/mpq.2004.0018

Gatch, M. B., & Osborne, J. G. (1989). Transfer of contextual stimulus function via equivalence class development. *Journal of the Experimental Analysis of Behavior, 51*, 369–378. doi:10.1901/jeab.1989.51-369

Gold, R., & Faust, M. (2010). Right hemisphere dysfunction and metaphor comprehension in young adults with Asperger syndrome. *Journal of autism and developmental disorders*, *40*, 800–811. doi:10.1007/s10803-009-0930-1

Gore, N. J., Barnes-Holmes, Y., & Murphy, G. (2010). The relationship between intellectual functioning and relational perspective-taking. *International Journal of Psychology and Psychological Therapy, 1*, 1–17. Retrieved from http://www.ijpsy.com/.

Gorham, M., Barnes-Holmes, Y., Barnes-Holmes, D., & Berens, N. (2009). Derived comparative and transitive relations in young children with and without autism. *The Psychological Record, 59*, 221–246. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Greer, R. D., & Keohane, D. (2004). A real science and technology of teaching. In J. Moran & R. Malott, (Eds.*)*, *Evidence-Based Educational Methods* (pp. 23–4). New York, NY: Elsevier/Academic Press.

Greer, R. D. & Ross, D. E. (2008). *Verbal behavior analysis: Inducing and expanding new verbal capabilities in children with language delays*. New York, NY: Allyn & Bacon.

Greer, R. D., & Speckman, J. (2009). The integration of speaker and listener responses: A theory of verbal development. *The Psychological Record*, *59*, 449–488. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Greer, R. D., Stolfi, L., & Pistoljevic, N. (2007). Emergence of naming in preschoolers: A comparison of multiple and single exemplar instruction. *European Journal of Behavior Analysis, 8*, 109. Retrieved from http://www.ejoba.org/.

Greer, R. D., Stolfi, L., Chavez-Brown, M., & Rivera-Valdes, C. (2005). The emergence of the listener to speaker component of naming in children as a function of multiple exemplar instruction. *The Analysis of Verbal Behavior, 21*, 123. Retrieved from http://www.abainternational.org/journals/the-analysis-of-verbal-behavior.aspx.

Halvey, C. & Rehfeldt, R. A. (2005). Expanding vocal requesting repertoires via relational responding in adults with severe developmental disabilities. *The Analysis of Verbal Behavior, 21*, 13. Retrieved from http://www.abainternational.org/journals/the-analysis-of-verbal-behavior.aspx.

Hayes, S. C. (1991). A relational control theory of stimulus equivalence. In L. J. Hayes & P. N. Chase (Eds.), Dialogues on verbal behavior (pp. 19–40). Reno, NV: Context.

Hayes, S. C. (1992). Verbal relations, time, and suicide. In S. C. Hayes & L. J. Hayes (Eds.), *Understanding verbal relations* (pp. 109–118). Reno, NV: Context Press.

Hayes, S. C., Barnes-Holmes, D., & Roche, B. (2001). *Relational frame theory: A post-Skinnerian account of human language and cognition.* New York, NY: Kluwer Academic/Plenum.

Hayes, S. C., Fox, E., Gifford, E. V., Wilson, K. G., & Barnes-Holmes, D. Healy. O. (2001). Derived relational responding as learned behavior. In S. C. Hayes, D. Barnes-Holmes & B. Roche (Eds.), *Relational frame theory: A post-Skinnerian account of human language and cognition* (pp. 21–49). New York, NY: Kluwer Academic/Plenum.

Holth, P., & Arntzen, E. (1998). Stimulus familiarity and the delayed emergence of stimulus equivalence or consistent non-equivalence. *The Psychological Record*, *48*, 81–110. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Horne, P. J. & Lowe, C. F. (1996). On the origins of naming and other symbolic behavior. *Journal of the Experimental Analysis of Behavior, 65*, 185–241. doi:10.1901/jeab.1996.65-185

Horne, P. J., Hughes, J. C., & Lowe, C. F. (2006). Naming and categorization in young children: IV: Listener behavior training and transfer of function. *Journal of the Experimental Analysis of Behavior, 85*, 247–273. doi:10.1901/jeab.2006.125–04

Horne, P. J., Lowe, C. F., & Harris, F. D. A. (2007). Naming and categorization in young children: V. Manual sign training. *Journal of the Experimental Analysis of Behavior, 87*, 367–381. doi:10.1901/jeab.2007.52-06

Keintz, K. S., Miguel, C. F., Kao, B., & Finn, H. E. (2011). Using conditional discrimination training to produce emergent relations between coins and their values in children with autism. *Journal of Applied Behavior Analysis*, *44*, 909. doi:10.1901/jaba.2011.44–909

Klin, A., Schultz, R., & Cohen, D. (2000). Theory of mind in action: developmental perspectives on social neuroscience. In Baron-Cohen, S., Tager-Flusberg, H., & Cohen, D. (Eds.) *Understanding Other Minds: Perspectives from developmental neuroscience*. (pp. 357–388). Oxford, England: Oxford University Press.

LeBlanc, L. A., Miguel, C. F., Cummings, A. R., Goldsmith, T. R., & Carr, J. E. (2003). The effects of three stimulus-equivalence testing conditions on emergent US geography relations of children diagnosed with autism. *Behavioral Interventions, 18*, 279–289. doi:10.1002/bin.144

Lipkens, R., Hayes, S. C., & Hayes, L. J. (1993). Longitudinal study of the development of derived relations in an infant. *Journal of Experimental Child Psychology, 56*, 201. doi:10.1006/jecp.1993.1032

Lovaas, O. I. (1987). Behavioral treatment and normal educational and intellectual functioning in young autistic children. *Journal of Consulting and Clinical Psychology, 55*, 3–9. doi:10.1037/0022-006X.55.1.3

Lowe, C. F., Horne, P. J., & Hughes, J. C. (2005). Naming and categorization in young children: III. Vocal tact training and transfer of function. *Journal of the Experimental Analysis of Behavior, 83*, 47–65. doi:10.1901/jeab.2005.31-04

Lowenkron, B. (1998). Some logical functions of joint control. *Journal of the Experimental Analysis of Behavior*, *69*, 327–354. doi:10.1901/jeab.1998.69-327

Luciano, C., Rodríguez, M., & Mañas, I. (2009). Acquiring the earliest relational operants: Coordination, distinction, opposition, comparison, and hierarchy. In R. A. Rehfeldt & Y. Barnes-Holmes (Eds.), Derived relational responding applications for learners with autism and other developmental disabilities: A progressive guide to change (pp 149-172). Oakland, CA: New Harbinger.

Luciano, C., Gomez-Becerra, I., & Rodriguez-Valverde, M. (2007). The role of multiple-exemplar training and naming in establishing derived equivalence in an infant. *Journal of the Experimental Analysis of Behavior, 87*, 349–365. doi:10.1901/jeab.2007.08-06

Makrygianni, M. K., & Reed, P. (2010). A meta-analytic review of the effectiveness of behavioural early intervention programs for children with autistic spectrum disorders. *Research in Autism Spectrum Disorders*, *4*, 577–593. doi: 10.1016/j.rasd.2010.01.014

Malott, R. W. (2003). Behavior analysis and linguistic productivity. *The Analysis of Verbal Behavior, 19*, 11–18. Retrieved from http://www.abainternational.org/journals/the-analysis-of-verbal-behavior.aspx.

May, R. J., Hawkins, E., & Dymond, S. (2013). Brief report: effects of tact training on emergent intraverbal vocal responses in adolescents with autism. *Journal of Autism and Developmental Disorders*, *43,* 996–1004. doi:10.1007/s10803-012-1632-7

McDonagh. E. C, McIlvane, W. J., & Stoddard, L. T. (1984). Teaching coin equivalences via matching to sample. *Applied Research in Mental Retardation. 5*, 177–197. doi:10.1016/S0270-3092(84)80001-6

McHugh, L., Barnes-Holmes, Y., & Barnes-Holmes, D. (2004). Perspective-taking as relational responding: A developmental profile. *The Psychological Record, 54*, 115–144. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

McHugh, L., Barnes-Holmes, Y., Barnes-Holmes, D., Stewart, I., & Dymond, S. (2007). Deictic relational complexity and the development of deception. *The Psychological Record, 57*, 517–531. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

McLay, L. K., Sutherland, D., Church, J., & Tyler-Merrick, G. (2013). The formation of equivalence classes in individuals with autism spectrum disorder: A review of the literature. *Research in Autism Spectrum Disorders*, *7*, 418–431. doi:10.1016/j.rasd.2012.11.002

Michael, J. (1988). Establishing operations and the mand. *The Analysis of Verbal Behavior*, *6*, 3–9. Retrieved from http://www.abainternational.org/journals/the-analysis-of-verbal-behavior.aspx.

Miguel, C. F., Yang, H. G., Finn, H. E., & Ahearn, W. H. (2009). Establishing derived textual control in activity schedules with children with autism. *Journal of Applied Behavior Analysis, 42*, 703–709.

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*, 233–251. doi:10.1007/s40732-014-0032-0 .

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*, 1149–53. doi:10.1007/s10803-010-0968-0

Murphy, C., & Barnes-Holmes, D. (2009a). Derived more-less relational mands in children diagnosed with autism. *Journal of Applied Behavior Analysis*, *42*, 253–268. doi:10.1901/jaba.2009.42-253

Murphy, C., & Barnes-Holmes, D. (2009b). Establishing derived manding for specific amounts with three children: An attempt at synthesizing Skinner's Verbal Behavior with relational frame theory. *The Psychological Record*, *59*, 75–92. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Murphy, C., & Barnes-Holmes, D. (2010). Establishing complex derived manding in children with and without a diagnosis of autism. *The Psychological Record*, *60*, 489–504. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Murphy, C., Barnes-Holmes, D., & Barnes-Holmes, Y. (2005). Derived manding in children with autism: Synthesizing Skinner's verbal behavior with relational frame theory. *Journal of Applied Behavior Analysis, 38*, 445–462. doi:10.1901/jaba.2005.97-04

National Autism Center (2009). *National standards report*. Randolph, MA: Author.

National Research Council (2001). Educating children with autism. Washington, DC: The National Academies Press.

O'Connor, J., Rafferty, A., Barnes-Holmes, D., & Barnes-Holmes , Y. (2009). The role of verbal behavior, stimulus nameability, and familiarity on the equivalence performances of autistic and normally developing children. *The Psychological Record, 59,* 53–74. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Ogawa, A., Yamazaki, Y., Ueno, K., Cheng, K., & Iriki, A. (2010). Neural correlates of species-typical illogical cognitive bias in human inference. *Journal of Cognitive Neuroscience, 22*, 2120–2130. doi:10.1162/jocn.2009.21330

O'Hora, D., Barnes-Holmes, D., Roche, B., & Smeets, P. M. (2004). Derived relational networks and control by novel instructions: A possible model of generative verbal responding. *The Psychological Record, 54*, 437–460. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Pérez-González, L. A., Garcia-Asenjo, L., Williams, G., & Carnerero, J. J. (2007). Emergence of intraverbal antonyms in children with pervasive developmental disorder. *Journal of Applied Behavior Analysis, 40*, 697–701. doi:10.1901/jaba.2007.697-701

Persicke, A., Tarbox, J., Ranick, J., & St Clair, M. (2012). Establishing metaphorical reasoning in children with autism. *Research in Autism Spectrum Disorders*, *6*, 913–920. doi:10.1016/j.rasd.2011.12.007

Perner, J. (1988). Developing semantics for theories of mind: From propositional attitudes to mental representation. In J. W. Astington, P. L. Harris, & D. R. Olson (Eds.), *Developing theories of mind*. (pp. 141–172). New York, NY: Cambridge University Press.

Perner, J. (1991). *Understanding the representational mind*. Cambridge, MA: The MIT Press.

Perry, R., Cohen, I., & DeCarlo, R. (1995). Case study: Deterioration, autism, and recovery in two siblings. *Journal of the American Academy of Child and Adolescent Psychiatry, 34,* 232–237. doi:10.1097/00004583-199502000-00019

Reese, H. W. (1968). *The perception of stimulus relations: Discrimination learning and transposition.* New York, NY: Academic Press.

Rehfeldt, R. A. (2011). Toward a technology of derived stimulus relations: An analysis of articles published in the journal of applied behavior analysis, 1992-2009. *Journal of Applied Behavior Analysis, 44*, 109–119. doi:10.1901/jaba.2011.44-109

Rehfeldt, R. A., & Barnes-Holmes, Y. (2009). *Derived relational responding applications for learners with autism and other developmental disabilities: A progressive guide to change.* Oakland, CA: New Harbinger.

Rehfeldt, R. A. & Root, S. L. (2005). Establishing derived requesting skills in adults with severe developmental disabilities. *Journal of Applied Behavior Analysis, 38*, 101–5. doi:10.1901/jaba.2005.106-03

Rehfeldt, R. A., Dillen, J. E., Ziomek, M. M., & Kowalchuk, R. K. (2007). Assessing relational learning deficits in perspective-taking in children with high functioning autism spectrum disorder. *The Psychological Record, 57*, 23–47. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Roche, B., & Barnes, D. (1997). A transformation of respondently conditioned stimulus function in accordance with arbitrarily applicable relations. *Journal of the Experimental Analysis of Behavior*, *67*, 275–301. doi:10.1901/jeab.1997.67-275

Rosales, R. & Rehfeldt, R. A. (2007). Contriving transitive conditioned establishing operations to establish derived manding skills in adults with severe developmental disabilities. *Journal of Applied Behavior Analysis, 40*, 105–121. doi:10.1901/jaba.2007.117-05

Schusterman, R. J., & Kastak, D. (1993). A California sea lion (Zalophus californianus) is capable of forming equivalence relations. *The Psychological Record*, *43*, 823–839. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Sidman, M. (1994). *Equivalence relations and behavior: A research story*. Boston, MA: Authors Cooperative.

Sidman, M. (2000). Equivalence relations and the reinforcement contingency. *Journal of the Experimental Analysis of Behavior, 74*, 127–146. doi:10.1901/jeab.2000.74-127

Sidman, M., Cresson, O., & Wilson-Morris, M. (1974). Acquisition of matching to sample via mediated transfer. *Journal of the Experimental Analysis of Behavior, 22*, 261–273. doi:10.1901/jeab.1974.22-261

Sidman, M. (1971). Reading and auditory-visual equivalences. *Journal of Speech and Hearing Research, 14*, 5–13. doi:10.1044/jshr.1401.05

Skinner, B. F. (1957). *Verbal behavior*. New York, NY: Appleton Century

Sprinkle, E. C., & Miguel, C. F. (2013). Establishing derived textual activity schedules in children with autism. *Behavioral Interventions*, *28* 185–202. doi:10.1002/bin.1365

Stewart, I., & Barnes-Holmes, D. (2001a). Relations among relations: Analogies, metaphors, and stories. In S. C. Hayes, D. Barnes-Holmes & B. Roche (Eds.), *Relational frame theory: A post-Skinnerian account of human language and cognition.* (pp. 73–86). New York, NY: Kluwer Academic/Plenum.

Stewart, I., & Barnes-Holmes, D. (2001b). Understanding metaphor: A relational frame perspective. *The Behavior Analyst, 24*, 191–199. Retrieved from http://www.abainternational.org/journals/the-behavior-analyst.aspx.

Stewart, I., & McElwee, J. (2009). Relational responding and conditional discrimination procedures: An apparent inconsistency and clarification. *The Behavior Analyst, 32*, 309–317. Retrieved from http://www.abainternational.org/journals/the-behavior-analyst.aspx.

Stewart, I. Barnes-Holmes, D., & Roche, B. (2004). A functional analytic model of analogy using the Relational Evaluation Procedure. *The Psychological Record, 54*, 531–552. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Sundberg, M. L. (2008). *VB-MAPP: Verbal Behavior Milestones Assessment and Placement Program - Protocol.* Concord, CA: AVB Press.

Sundberg, M. L. & Michael, J. (2001). The benefits of Skinner's analysis of verbal behavior for children with autism. *Behavior Modification, 25*, 698–724. doi:10.1177/0145445501255003

Walsh, S., Horgan, J., May, R. J., Dymond, S., & Whelan, R. (2014). Facilitating relational framing in children and individuals with developmental delay using the relational completion procedure. *Journal of the Experimental Analysis of Behavior*, *101*, 51–60. doi:10.1002/jeab.66

Weil, T. M., Hayes, S. C., & Capurro, P. (2011). Establishing a deictic relational repertoire in young children. *The Psychological Record, 61*, 371–390. Retrieved from http://www.abainternational.org/journals/the-psychological-record.aspx.

Wulfert, E., & Hayes, S. C. (1988). Transfer of a conditional ordering response through conditional equivalence classes. *Journal of the Experimental Analysis of Behavior,* 50, 125-144. doi:10.1901/jeab.1988.50-125