TECHNOLOGY FOR ESTABLISHING DEICTIC REPERTOIRES IN AUTISM

A Dissertation
Submitted to
the Temple University Graduate Board

In Partial Fulfillment
of the Requirements for the Degree
DOCTOR OF PHILOSOPHY

By
Shawn P. Gilroy
August 2014

Examining Committee Members:

Catherine Fiorello, Advisory Chair, School Psychology/ Psychological, Organizational, and Leadership Studies (POLS)
Matt Tincani, Advisory Chair, Psychological, Organizational, and Leadership Studies (POLS)
Donald Hantula, Psychology, Psychology
Catherine Schifter, Examining Chair, Psychological, Organizational, and Leadership Studies (POLS)
S. Kenneth Thurman, Psychological, Organizational and Leadership Studies (POLS)

ABSTRACT

Children on the autism spectrum often demonstrate little variability in their use of language and interaction in social situations. Some of these difficulties have historically been attributed to weak or absent perspective-taking abilities. Relational Frame Theory has recently emerged as a framework for understanding complex social behavior and cognition, including perspective-taking, from an ecological viewpoint. Previous studies have illustrated the applicability of such a framework with children from ranging from pre-school to school-age, with and without an Autism Spectrum Disorder. Despite early support for these approaches, researchers have strived to deliver these intervention protocols in more naturalistic and naturally-occurring contexts. The purpose of this study was to further extend a relational training protocol into naturalistic contexts (e.g., social situations free of adult prompting). This study utilized a novel protocol in which a same-aged peer delivered an intervention to improve the relational responding thought to underpin perspective-taking abilities. Through developing software specific to relational responding and child-use, school-age children appropriately delivered a multiple exemplar teaching protocol across multiple levels of difficulty. Results indicate that a relational training protocol delivered using technology was effective in improving relational repertoires (e.g., perspective-taking), could be implemented by a school-age student and was preferred over traditional teaching methods.

TABLE OF CONTENTS

PAGE

LIST OF TABLES

Tables

LIST OF FIGURES

Figures

CHAPTER 1
INTRODUCTION

Deficits in age-appropriate social interaction in a variety of social situations are often a hallmark feature of autism spectrum disorders (ASD) and intellectual disabilities (Baron-Cohen, Tager-Flusberg, & Cohen, 2000; Hyman & Towbin, 2009; Scattone, 2007). There continues to be strong support for using applied behavior analysis to remediate academic, behavioral and social needs of these populations (Foxx, 2008; Rogers & Vismara, 2008). Through the use of behavior analysis, individuals with these deficits can be taught to request, comment and respond within a continuum of social situations (Skinner, 1957; Koegel, Koegel, Harrower, 1999). However, despite a range of strategies for teaching social behavior, best practices cannot guarantee that skills taught in the training situation will emerge in novel contexts.

Children on the autism spectrum often demonstrate little variability in their use of language and interaction in social situations (Koegel et al., 1999). In addition to little variability, these individuals more often respond to language in an overly literal manner (Baron-Cohen, 1997; Happe, 1996). In these types of instances, these learners often cannot distinguish the informal and unspoken relations present in jokes, inflections and other forms of more complex language (Baron-Cohen, 1995; Baron-Cohen, 1997; McHugh, Barnes-Holmes & Barnes-Holmes, 2009). Children and adults who display this type of deficit (e.g., failing to discriminate the "unspoken" components of language) may accurately discriminate and respond to the behavior of others by the formal characteristics of their behavior (e.g., a comment from male peer) but respond less accurately to the informal characteristics of their behavior (e.g., mistaking a sarcastic remark for a compliment) (Baron-Cohen, 1997; McHugh et al., 2009). Individuals that cannot readily perform these types of discriminations are unlikely to demonstrate appropriate, or effective, interaction in natural social situations (Rehfeldt, Dillen, Ziomek & Kowalchuck, 2007; McHugh, Barnes-Holmes, O'Hora & Barnes-Holmes, 2004).

Relational Frame Theory has emerged as a lens with which to examine a wide range of complex and dynamic human repertoires through analyses of the derived relational responding necessary to perform them (McHugh et al., 2004; McHugh et al., 2009). Put simply, relational responding refers to how organisms behave in response to certain stimuli in relation to other stimuli (Hayes, Barnes-Holmes & Roche, 2001). Though a range of complex repertoires, including perspective-taking, have been taught using traditional behavior analytic approaches (LeBlanc, Coates, Daneshvar, Charlop-Christy, Morris & Lancaster, 2003), further analysis of the relational responding necessary to demonstrate (e.g., derive) these types of repertoires has offered additional levels of analysis. Relational responding, or the individual's response to a relational frame, emerged from research on the well-established principles of stimulus equivalence (Hayes & Kohlenberg, 1991; Lipkins, Hayes & Hayes, 1993; Dymond & Barnes, 1994; Dymond & Barnes, 1995; Hayes, Fox, Gifford, Wilson, Barnes-Holmes & Healy, 2001; Barnes-Holmes, Barnes-Holmes, Smeets, Cullinan & Leader, 2004; Hobson & Garcia-Perez, 2010). Relational frames extended the fundamental relations in stimulus equivalence (e.g., reflexivity, symmetry and transitivity) from specific to arbitrary stimuli (Hayes, 1991; Hayes, 1992). Where stimulus equivalence could predict a relation (e.g., conditional discrimination) such as "larger" between two specific stimuli (e.g., a large cup and a small cup), relational frames could predict a relation between any two (or more) arbitrary stimuli (e.g. a bike and a cup). Relational frame theory granted an additional level of interpretation to account for how and where organisms demonstrate complex behavior based on any number of contextual cues (e.g., differences in sizes, colors, locations, etc.) (Barnes, 1994). Among the families of relational frames, there are frames of distinction (e.g., the relation is difference), opposition (e.g., the relation is opposing), comparison (e.g., the relation states one stimulus is better, bigger, etc.), spatial (e.g., one stimulus may be nearer or further), temporal (e.g., one stimulus may occur sooner, later), hierarchical (e.g., some stimuli may be members of a larger class or category), causality (e.g., if and then relations), and deictic (e.g., stimuli relate differently to different individuals) (Hayes et al., 2001). Deictic frames have emerged as an effective framework for analyzing the relations between individuals (e.g., relations present to the speaker differing from that of a listener) in the social context (Dymond & Hayes, 1995; Hayes et al., 2001). Relational frame researchers have claimed that a deictic framing repertoire is necessary for a range of social behavior, including the ability to empathize and take the perspective of someone, or something, else (McHugh et al., 2004; McHugh et al., 2007; Rehfeldt, Dillen, Ziomek & Kowalchuck, 2007; McHugh et al., 2009; Rehfeldt & Barnes-Holmes, 2009). These authors claimed that deictic framing, among other types of relational responding, are forms of operant behavior that must be shaped throughout the lifespan, similar to that of generalized imitation and other overarching classes of behavior (Hayes et al., 2001; McHugh et al., 2004; McHugh et al., 2007).

Several teaching protocols have been developed based on the original methods developed in the seminal McHugh et al. (2004) study. Methods for assessing and teaching deictic framing have been customized for pre-school young children (Weil, Hayes & Capurro, 2011), school aged children (Heagle & Rehfeldt, 2006) and children with high functioning autism (Rehfeldt et al., 2007). The latest methods to teach deictic framing have since incorporated more naturalistic teaching methods by incorporating the narrative content from children’s stories (Davlin, Rehfeldt, & Lovett, 2011) as well as the traditional tabletop teaching methods found in preschool teaching (Weil et al., 2011). All of these methods produced improvement in participants' accurate responding to deictic frames. Beyond improvement specific to deictic framing tasks, young children in the Weil et al. (2011) study demonstrated corresponding gains on a range of "false belief" tasks in young children, thought to indicate improved perspective-taking (Howlin, Baron-Cohen & Hadwin 1999). These "false belief" tasks involve inferring the incorrect belief and predicting the behavior of others, a commonly used measure of perspective-taking abilities (Baron-Cohen, 1995; Howlin et al., 1999; Howlin et al., 1999, Baron-Cohen, 2000) in children and adults.

Additional research into teaching deictic framing could potentially improve, or at least supplement, interventions designed to remediate the perspective-taking and social skill deficits commonly found in the autism spectrum disorder. Recent research with young children indicated that significant improvements in how accurately and fluently children can derive deictic relations related to gains on several of the traditional measures of perspective-taking skills (e.g., theory of mind and "false belief" tasks) (Weil et al., 2011). However, the currently available methods for teaching deictic relations are delivered in the context of an adult delivering instruction to a child. In the ASD literature, peer-mediated interventions have demonstrated improved generalization of skills to same-age peers over interventions implemented by adults alone (Zhang & Wheeler, 2011). Given that taking the perspective of another (e.g., deriving deictic relations) can be taught in a structured context, including peers in such a context could provide an advantage towards generalizing this form of responding to other peers or social situations.

The inclusion of peers in the delivery of deictic framing interventions could be accomplished through the use of technology. Such an approach would incorporate computer-based instructional methods that had produced improvements in deictic framing in earlier studies (McHugh et al., 2004; Rehfeldt et al., 2007). In addition to extending from previously effective methods, the addition of technology to this type of intervention could require far fewer demands from those teaching the protocol. For example, a tablet-based application could be designed to mediate reinforcement, provide error correction and collect data. If technology could leverage the limited capacity of children, an adult might not be necessary to implement an intervention package at all, limiting the likelihood that generalization would not extend beyond adults (Pellechia & Hineline, 2007). As of yet, there has not been a study that has utilized technology with a peer delivering an intervention protocol in this way. Additional research into such a method of delivery could offer promise of a way to deliver a previously unfeasible intervention package, due to the inherent effort and complexity, while retaining the additional value of learning from a same-age peer.

Problem statement

In the field of special education, teachers and clinicians continue to search for newer and more improved methods to remediate the social and language deficits of children with ASD. There is a range of interventions available specific to academic instruction, but interventions targeting social deficits have demonstrated mixed success with respect to generating novel social behavior (LeBlanc et al., 2003). Many of the mainstream interventions developed to improve social skills were developed following research by psychologists embracing the theory of mind framework (ToM) (Fay, 1979; Perner, Leekam, & Wimmer, 1987; Perner, Frith, & Leekam, 1989; Howlin, Baron-Cohen, & Hadwin, 1999; Hobson & Meyer, 2005). Many ToM interventions focus primarily on correctly identifying the informational states (e.g., feelings, thoughts, etc.) of others (Baron-Cohen, 1995; Baron-Cohen, Tager-Flusberg & Cohen, 2000) over the contextual cues for such behavior. Just recently, an interpretation of social behavior using relational frames has contributed a newer framework to interpret, and teach, a range of complex social behavior (e.g., perspective-taking) (McHugh et al., 2004). Deictic framing, the primary type of relational responding necessary for perspective-taking, refers to how an individual discriminates the unspoken (e.g., informal) relations between individuals (e.g., differences from self to peers, adults to other adults, etc.) and stimuli in the environment (Dymond & Barnes, 1994; Dymond & Barnes, 1995; Hayes et al., 2001; McHugh et al., 2004; Heagle & Rehfeldt, 2006). Despite increasing support for using deictic framing protocols as a method for teaching relational responding (Heagle et al., 2006; Davlin et al., 2011; Weil et al., 2011), fewer studies have demonstrated improvements with children with high functioning autism (Rehfeldt et al., 2007). Given the relative complexity of a deictic training protocol, options for a peer-mediated delivery were very limited. Recent developments in the portability of, and access to, technology have permitted additional opportunities for delivering complex interventions. Software customized for use by young children could be used to guide the delivery of a complex intervention package, as implemented by a child, to ensure accurate and realistic training in social situations.

Research questions

1. Can a typically-developing peer be trained to deliver simple, reversed, and double reversed instances of framing using technology?
2. What are the effects of instruction using reinforcement and feedback delivered via a mobile device on responding of children with ASD?
3. Will training on deictic framing result in improvements on traditional tests of Theory of Mind (Levels III-IV-V)?

CHAPTER 2
LITERATURE REVIEW

Autism Spectrum Disorders

In the fields of psychology and special education, there have been continued strides towards improving intervention and outcomes for children, notably for children with autism spectrum disorders (ASD) (Foxx, 2008). There is strong support for using the principles of applied behavior analysis (ABA) to remediate the academic, behavioral, and social needs of these populations (Foxx, 2008). Early, intensive intervention using ABA is the only intervention that has met criteria for being a "well-established" treatment for ASD (Rogers & Vismara, 2008). Researchers continue to expand and refine academic and behavior management interventions, but less progress has been made for the remediation of social deficits. Given the highly variable nature and scope of social interaction, there are disagreements upon which types of skills to target and how one should go about providing remediation of social skills deficits (Scattone, 2007). Social skills also present greater difficulty for educators working with children with autism, as skills taught to mastery with adults do not readily generalize to new situations or to same-age peers (Pellechia & Hineline, 2007).

Approaches for Remediating Social Deficits

Varying schools of thought offer differing theories as to which skills underpin complex social behavior and how best to remediate those deficits (McHugh et al., 2004). Many of these approaches offering conflicting, even opposing assumptions regarding the development of social behavior (McHugh et al., 2004; Weil et al., 2011). Despite competing viewpoints, relatively few interventions have emerged to develop and remediate perspective-taking in autism, specifically (Howlin et al., 1999; LeBlanc et al., 2003; Rehfeldt et al., 2007). The current commercially available interventions focus on teaching learners to guess the informational states of others (e.g., to "mind read") (Howlin et al., 1999; Baron Cohen, 2000), rather than teaching them to respond to a range of environmental (e.g., contextual) cues (McHugh et al., 2004; McHugh et al., 2006; Rehfeldt et al., 2007). For example, a student may be taught to say something nice to another boy who is smiling (e.g., because smiling suggests a pleasant informational state) in a developmentally-based "mindreading" approach while an environmental-based approach would involve a student responding to how events are framed in the environment (e.g., I can play with another boy since I am on the playground and not in the classroom). In these examples, the environmental approach is more sensitive to the on-going context more than traditional "mind reading" approaches, which focus largely on recognizing the facial and affective cues that inform guesses to an informational state (e.g., smiling means fun). Focusing on the identification of personal and affective cues is also limiting, as the presence of a smile does not necessarily mean that the person smiling is laughing or happy. These limitations have been noted as one of many possible reasons that "mindreading" approaches often do not reliably produce improvements in general social behavior, especially in the cases of ASD and other developmental disabilities (Klin, 2000; Koenig, De Los Reyes, Cichetti, Scahill & Klin, 2009). Beyond insensitivity to environmental factors, "mindreading" approaches are driven by multidimensional psychological constructs, which themselves present unique challenges and considerations for developing instructional programming, clinical intervention and the evaluation of outcomes (De Los Reyes & Kazdin, 2006).

Relational Frame Theory has recently emerged as a framework for analyzing how the arrangement of stimuli in the environment influence behavior. The theory (RFT) holds that the "unseen", or informal, relations between stimuli serve as powerful cues for behavior (e.g., our response to friends on the playground differs from friends in the classroom). An environmentally-driven account is more desirable than a purely developmental account, as insensitivity to subtle environmental cues has been implicated as one of the many reasons social skills training may not produce improvements in social behavior (Klin, 2000). The arrangement of certain events such as these are termed relational frames (specifically deictic frames) and have recently been researched as a promising set of skills relevant to developing complex social behavior- especially in the case of ASD (Rehfeldt et al., 2007; McHugh et al., 2009). A RFT account of complex social behavior holds that these types of repertoires are driven by the environment, shaped by on-going reinforcement and teaching and that many complex forms of human behavior are learned over time and not purely innate or the product of biology (Hayes et al., 2001; McHugh et al., 2004).

Psychology and a Theory of Mind

A Theory of Mind was developed in order to describe how individuals come to understand one another (Baron-Cohen, 1995; Howlin et al., 1999; Baron-Cohen et al., 2000). Theory of Mind exists as a theoretical construct to describe the range of conceptual changes that occur in early childhood (Wellman, Cross & Watson, 2001). Seen as the incorporation of "everyday" and "folk" psychologies, a ToM account emphasizes the "seeing" of oneself and others in terms of mental states (Wellman et al., 2001). Through the course of biological development and maturation, individuals are thought to develop the capacity to recognize a range of mental states including desires, emotions, beliefs and reasoning (Wellman, 1990; Flavell & Miller, 1998). Per a ToM account, the ability to understand the mental states of oneself and another comes about through the practice of "mindreading" (Baron-Cohen, 1995; Howlin et al., 1999). The understanding of mental states is thought to allow the individual to realize that such states may come to manifest with overt behavior (e.g., thinking leads to doing) (Howlin et al., 1999; Wellman et al., 2001). The same distinction also serves to separate the overt from covert (e.g., the mind vs. the real world), as illustrated in *Figure 1*.

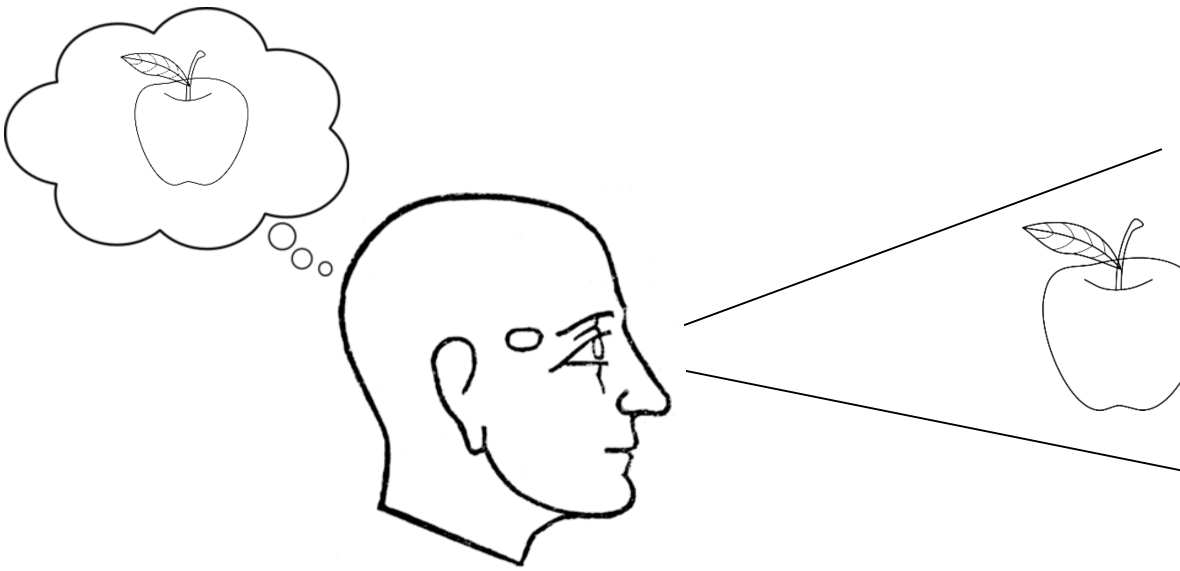


Figure 1. Understanding others in terms of mental states

According to Baron-Cohen, a process of "mindreading" entails determining the informational, or mental, states of another individual and responding to them accordingly (Baron-Cohen, 1995; Plastow, 2012). A child able to "mindread" or "mentalize" should be able to determine the beliefs, desires and intentions of others around them and make prediction of how others might behave (Plastow, 2012). The ability to perform these acts is thought to be the result of biological development, free of any specific linguistic or cognitive demands (Baron-Cohen, 1995; Howlin et al., 1999; Baron-Cohen, 2000; Plastow, 2012). In the case of autism specifically, the social "disconnectedness" was historically thought to be a failure to "mindread"- to see others in terms of their "inner mental lives" (Baron-Cohen, 1995). Many individual with autism demonstrate widespread deficits in a range of age-appropriate social interactions (Baron-Cohen et al., 2000; Hyman & Towbin, 2009; Scattone, 2007). These social difficulties have historically been analyzed and interpreted through the lens of ToM and developmental psychology and have only more recently been researched by mainstream behavioral psychology (Fay, 1979; Perner, Leekam & Wimmer, 1987; Leekam & Perner, 1991; Baron-Cohen, 1995; Howlin, Baron-Cohen & Hadwin, 1999; Heagle & Rehfeldt, 2006).

Mainstream research into ASD has often been conducted within the conceptual framework of developmental psychology, highlighting various potential neuropsychological states and the role biological maturation as the underlying mechanisms driving the development or delay of social behavior (Howlin et al., 1999, Baron-Cohen et al., 2000; McHugh et al., 2004). Within this vein of research, much of the research into social behavior has been conducted under the umbrella of the Theory of Mind (ToM) framework. The ToM framework makes use of psychological constructs to conceptualize how an individual progresses from basic social behavior (e.g., identifying thoughts) to more complex social behavior (e.g., empathy). Within the ToM framework young children progress through several neurodevelopmental stages, eventually developing the capacity to infer the informational states of others (e.g., true and false beliefs, emotions, etc.) as a result of on-going biological maturation (Baron-Cohen, 1995; Baron-Cohen et al., 2000). More simply, ToM states that social behavior should emerge as a result of on-going growth and development and is independent of environment, experience or language. Though thoroughly prevalent throughout the literature on ASD, many have critiqued the ToM framework for offering weak explanatory power, inconsistent outcomes, and little to no guidance on how to teach communication and social skills or progress or to advance development (McHugh et al., 2004; McHugh et al., 2004; Heagle & Rehfeldt, 2006; Koenig et al., 2009). Dr. Uta Frith, a pioneer in the development of the ToM theory, has herself noted that ToM is insufficient for explaining many aspects of social behavior and how it develops (Frith & Happe, 1994)

A growing loss of support for ToM research likely exists for many reasons (Klin, 2000; De Los Reyes & Kazdin, 2006; Koenig et al., 2009). Per the proponents of ToM, children should naturally progress through several neurodevelopmental stages until they can infer the informational states of others independent of training, language proficiency or experience (Baron-Cohen, 1995; Howlin et al., 1999; Baron-Cohen et al., 2000). Each of these stages in ToM is marked by the development of abilities to infer increasing complex information from others (e.g., others see things differently than we do, determining internal states, etc.) (Baron-Cohen et al., 2000). Researchers endorsing ToM have hypothesized that progression through all stages of ToM development is a prerequisite to the ability to assume the perspective of others, among a range of meaningful social and emotional behavior (Baron-Cohen, 1995; Howlin et al., 1999; Baron-Cohen et al., 2000). However, even within the literature on ToM, there is disagreement as to how, when, and by what processes, these types of abilities should occur (Hayes et al., 2001; McHugh et al., 2004; Heagle & Rehfeldt, 2006). While the ToM literature has been referenced with relatively widespread agreement by developmental psychology as an explanation of why individuals with ASD fail to develop complex language and social skills, this approach is lacking in identifying the external factors (e.g., teaching strategies, environmental mediators, etc.) that may influence how, when and how quickly learners acquire these types of skills (Klin et al., 2000; McHugh et al., 2004; Heagle & Rehfeldt, 2006; McHugh et al., 2007). A more comprehensive and environmentally-driven understanding of how these complex repertoires emerge could lead to the development of more effective teaching curricula and intervention programs for both early intensive education and school-age social skill instruction

(Klin et al., 2000; McHugh et al., 2004; Rehfeldt et al., 2007; Davlin et al., 2011; Weil et al., 2011). Additionally, a behaviorally-based framework would ameliorate many of the conceptual and measurement issues encountered when intervening and researching psychological constructs directly, a known limitation of the ToM approach (De Los Reyes & Kazdin, 2006).

Theory of Mind and the Development of Social Behavior

Despite widespread use in the literature, considerable debate continues regarding the utility of the Theory of Mind framework in explaining how complex social behavior develops. Beyond more immediate difficulties inferring the beliefs of others, developmental researchers ascribing to the ToM framework have cited deficits in language, humor and narrative communication to the same underlying deficits in ToM (Happe, 1993; Baron-Cohen, 1995; Baron-Cohen et al., 2000; Fisher & Happe, 2005). In the case of ASD, not having progressed through all stages has been cited as the underlying cause for the wide range of poor social and language development for these individuals (Happe, 1993; Baron-Cohen, 1995; Baron-Cohen et al., 2000). Per Baron-Cohen, a failure to develop these skills results in a state of "mind-blindness", rendering those with ASD unable to infer the informational states (e.g., thoughts, feelings, beliefs, etc.) of other peers and adults (Baron-Cohen et al., 1995; Baron-Cohen, 2000) and render them unable to view them in terms of the "inner selves", which is thought to be a result of their biological makeup. In addition to "mind-blindness", deficits in these abilities have been linked to difficulties with self- and bodily-awareness (Fay, 1979), difficulties forming relational concepts (Mossler, 1976; Perner et al., 1987) and language (Baron-Cohen, 1997), a failure of development in the biological structures supporting social connectedness (Hobson & Meyer, 2005), the inability to form mental meta-representations (Leekam, Perner, Healey, & Sewell, 2008), deficits in overall meta-representational abilities (Leekham & Perner, 1991), failures of executive functioning (Sabbagh & Taylor, 2000; Fisher & Happe, 2005), and deficits in general processing capacity (Halford, Wilson, & Phillips, 2008) for learners with and without ASD. However, despite a wealth research into these converging phenomena, researchers have not yet identified a specific genetic or biological structures that mediates how, when or whether an individual will or will not to progress through all stages of ToM (McHugh et al., 2004). Given that a specific biological structure or genetic marker has not been identified, many of the underlying biological or genetic assumptions cannot be verified.

Beyond the limited explanatory power of ToM, the theory itself has been critiqued over when an individual should progress through specific neurodevelopmental stages and when individuals should be able to infer certain informational states (McHugh et al., 2004; Weil et al., 2011). Researchers have observed conflicting accounts of neurological development, with some researchers claiming that components of ToM can be demonstrated as early as two (Howlin, 2008) or three years of age (Perner et al., 1987) and others suggesting that these components may not emerge until age seven years of age or even later (Fay, 1979). Given the ranging degrees of language proficiency within these age-ranges, many have questioned to whether such a task is actually a test of language proficiency instead of perspective-taking (Bloom & German, 2000). By simply making questions shorter and simpler (Freeman, Lewis & Doherty, 1991; Lewis & Osborne, 1990; Moses, 1993; Siegal & Beattie, 1991; Surian & Leslie, 1999) and making changes to the location of objects more apparent (Carlson, Moses & Hix, 1998; Wellman & Bartsch, 1988; Zaitchik, 1991), many children as early as two or three can demonstrate proficiency on all levels of ToM. Additionally, some researchers have critiqued the use of ToM measures as a litmus test for social abilities altogether, citing concerns that improvements on measures of ToM do not often relate to behavior in social (e.g., non-testing) environments at all

(Beeger, Gevers, Clifford, Verhoeve, Kat, Hoddenbach & Boer, 2011; Weil et al., 2011). As discussed in Weil et al. (2011), many of contrasting accounts suggests that external, environmental factors likely mediate the rates at which children come to acquire these repertoires.

Inherent within the actual conceptualization of ToM, unclear definitions and measurement of a psychological construct also eschews additional variability and challenges to measurement (De Los Reyes & Kazdin, 2006). As a result of these non-specific definitions and resulting challenges to measurement, the use of the ToM framework as one for teaching social behavior to clinical populations has met with mixed levels of success. Randomly controlled research trials have consistently demonstrated gains on tests of ToM with little-to-no improvements in any form of social behavior beyond the specific tests used to measure ToM (e.g., tests of true and false belief) (Steerneman, Jackson, Pelzer & Muris, 1996; Silver & Oakes, 2001; Fisher & Happe, 2005; Golan & Baron-Cohen, 2006; Gevers, Clifford, Mager & Boer, 2006; Beeger et al., 2011; Gould, Tarbox, O'Hora, Noone & Bergstrom, 2011). In addition to inconsistent outcomes and generalization, many have found the slightly different presentations of the ToM tasks (e.g., different characters, phrasing, etc.) can have substantial impact on overall accuracy regardless of changes in abilities, further casting doubt upon the social validity of these measures (van Buijsen, Hendriks, Ketelaars & Verhoeven, 2011). The authors of the van Burjisen et al., (2011) also claimed that the use of ToM as a framework of gauging social abilities is largely influenced by situational (e.g., toys, dolls, etc.) factors, possesses poor ceilings, is restrictive in the specific content sampled (e.g., basic informational states, simple analogues, disconnect from social situations, etc.) and questionable in its general social validity (e.g., demonstration of true/false belief does not ensure the use of true/false belief in socialization). In addition to a lack of improvement in social behavior beyond training in the trials referenced, child and parent self-reports did not endorse improvements on social behavior either (Steerneman et al., 1996; Geevers et al., 2006; Begeer et al., 2011). Given that improvements in social behavior were neither observed nor endorsed, a ToM framework may be insufficient as a conceptual basis, an assessment method and a framework for intervening on social behavior and that an environmentally-based account may be better to equipped to reveal the factors that most often mediate the development of social behavior (e.g., regardless of whether they passed tests of ToM or not) (Klin, 2000).

Capturing a Theory of Mind

Children with ASD, as well as related disabilities, typically demonstrate substantial difficulties responding to the social environment (Baron-Cohen, Leslie & Frith, 1985; Scattone, 2007; Foxx, 2008). Per developmental psychology and a ToM account, these overall difficulties were historically considered to be “meta-representational” deficits or failures to determine the underlying informational states of others (e.g., the motivations, beliefs and feelings of others) (Leslie, 1984). A failure to form these “metarepresentations” is thought to be the underlying cause for the social “disconnectedness” in ASD (Baron-Cohen, 1995). Per this view, individuals able to form “meta-representational” concepts should be able to correctly identify the informational states of others and distinguish the thoughts of others from their own, forming the basis of ToM (Wimmer & Perner, 1983; Baron-Cohen et al., 1985; Baron-Cohen et al., 2000). Historically, research into ToM has made use of procedures such as the “Sally Anne” task to gauge whether or not “meta-representational” abilities were demonstrated, see *Figure 2* (Wimmer & Perner, 1983). In research and practice, the “Sally Anne” tasks has been used as a procedure for determining whether an individual could accurately identify the “true” and “false” beliefs of another (e.g., a doll or person). In tests of ToM, an individual should be able to infer the informational states of others based whether those beliefs are accurate (e.g., true beliefs) or mistaken (e.g., false beliefs) (Wimmer & Perner, 1983; Baron-Cohen et al., 1985, Howlin et al., 1999). Children diagnosed with ASD or other developmental disabilities have historically failed to pass tests of true and false belief (Baron-Cohen, 1993). In the original example by Wimmer and Perner, if a young child is read a narrative when a character observes something to be true (e.g., a candy being placed in a box) and then learns that the same belief is no longer true (e.g., that the candy has been moved), the young child should be able to identify the incorrect informational state of the character (e.g., false belief), which is that the candy would be in its original space. Historically, individuals who cannot accurately identify a "false belief" are assumed to be at an earlier, delayed stage of neurodevelopment in ToM (Wimmer & Perner, 1983; Baron-Cohen et al., 1985; Howlin et al., 1999; Weil et al., 2011). The underlying assumption behind this deficit is that a failure to accurately identify these states would impair the individual's ability to determine how to respond in a range of social situations (Baron-Cohen, 1993; Howlin et al., 1999).

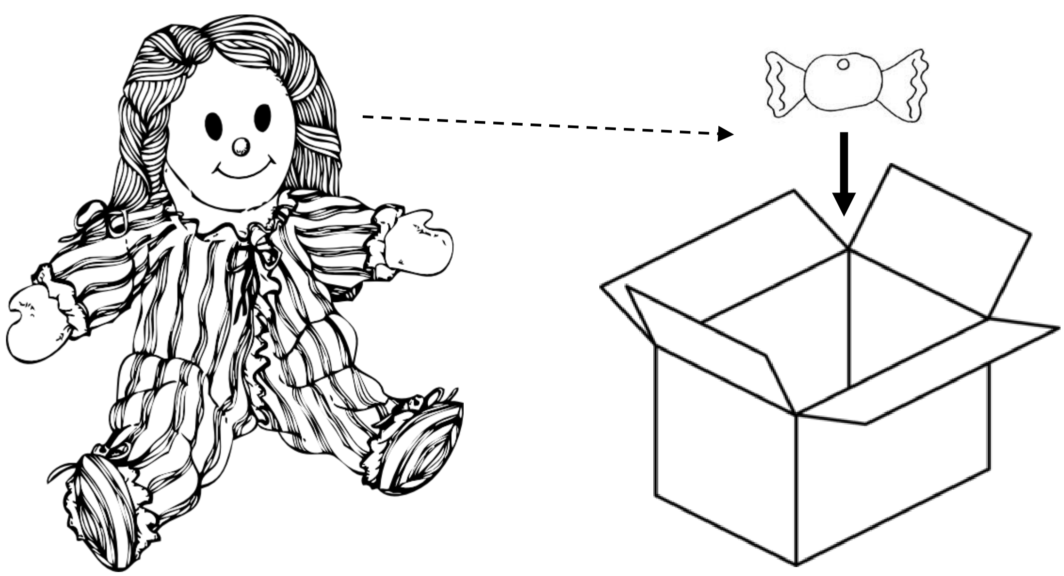


Figure 2. Diagram of Sally Anne "seeing" and "knowing" location

Within the mainstream ASD literature, researchers in social development have often designed their intervention and studies around the Theory of Mind framework (Howlin et al., 1999). The ToM framework consists of five distinct stages of development (Baron-Cohen, 1995; Howlin et al., 1999, Baron-Cohen et al., 2000), as displayed in Table 1. According to this model, the first level of perspective-taking consists of correctly discriminating visual information. In this stage, the individual should correctly discriminate between what they see and what another individual sees (e.g., simple visual perspective-taking). For example, each person sees what is in front of them. At the second level, visual discrimination becomes more complex, highlighting how position and perspective influences informational states (e.g., complex visual perspective-taking). In this stage, the child should be able to determine that a person in back of an object (e.g., a two-sided playing card) sees something different a person in front of the object. The third level of complexity involves the individual expressing the informational states of others, extending from the more basic ability to know that different positions lead to different beliefs. At this stage, the individual should correctly identify how another forms an informational state (e.g., what someone sees leads to what is "known"). At the fourth level, the individual should be able to determine another individual's factual beliefs based on a short analogue (e.g., determining a "true belief"). In this stage, a child should be able to make a prediction about a character's future action based on their informational stages (e.g. "He saw the candy get put in the cabinet before and will go back there to get it later"). The ability to predict how an individual will behave based on factual observations suggests that the individual can determine the "true beliefs" of another. (Howlin et al., 1999; Weil et al., 2011). The final stage expands from the previous stages by introducing an additional level of complexity -- an incorrect or "false belief". In the most commonly used analogue, the "Sally Anne" task, the individual is presented with a short analogue where they must identify the informational states of a character when their previous "true beliefs" are no longer accurate based on newly presented knowledge (e.g., a small piece of candy was moved without the character's knowledge) (Wimmer & Perner, 1983; Baron-Cohen et al., 1985, Howlin et al., 1999). In such a task, a child should correctly determine the true beliefs of the character based on the fact that the character had observed the events happen. When the child is presented with new knowledge that the previous fact is no longer true (e.g., the candy is no longer in the same place), the child should be able to identify that the character would behave under a "false belief." A child able to identify these false beliefs is said to have a theory of mind, namely that the thoughts of others are different from their own and should be able to demonstrate a range of social behavior (Howlin et al., 1999; Weil et al., 2011). Through teaching through these levels, regardless of language, the underlying cognitive and biological deficits are assumed to be ameliorated (Howlin et al., 1999).

Table 1. Stages of Theory of Mind

Stage	Level of Development	Example
1	Seeing is different from others	I see the apple and he sees the orange.
2	What's seen changes based on location (e.g. orientation)	I see the inside of the door and he sees the outside.
3	Seeing leads to knowing	I see the candy in the bag and I know candy is in the bag.
4	Predicting behavior based on knowledge	I saw the candy in the bag, I will go to the bag for candy.
5	Predicting behavior based on false knowledge	He saw candy go in the bag. I moved the candy. He will go to the bag for candy later anyway.

Behavioral Psychology and a Theory of Mind

In recent years, behavior analytic researchers have shown renewed interest in the development of complex social behavior, namely perspective-taking (Hayes, Barnes-Holmes & Roche, 2001; Hayes et al., 2001; McHugh et al., 2004; Rehfeldt et al., 2007; Rehfeldt & Barnes-Holmes, 2009; Davlin et al., 2001; Weil et al., 2011). Much of this renewed interested has followed the introduction of Relational Frame Theory (RFT) into the mainstream behavior analysis community (Hayes et al., 2001; McHugh et al., 2004; McHugh et al., 2006; Rehfeldt et al., 2007). Relational Frame Theory offered an expanded framework that extended the well-established theories of stimulus equivalence and rule-governed behavior (Barnes, 1994; Barnes-Holmes et al., 2004; Hayes et al., 2001). The extension of stimulus relations (e.g., stimulus equivalence relations) into the development of complex repertoires permitted researchers to further analyze complex repertoires (e.g., perspective-taking) from a purely environmental perspective. Per RFT, it is likely that advanced forms of language and cognition are made possible through the development of arbitrarily applicable relational responding (Hayes et al., 2001). For example, relational responding (e.g., determining the larger of two or more items) could become arbitrarily applicable (e.g., the response could emerge with any two or more items, people, events, etc.) as it continues to expand beyond the specific exemplars used initially in teaching (e.g., being taught the larger of two blocks and then determining the larger or two people) (Hayes et al., 2001). Through continued exposure to learning opportunities (e.g., multiple exemplar training) and the differential reinforcement resulting from them, a range of relational responding (e.g., relational frames) can expand to support a variety of complex and dynamic human behavior, including perspective-taking, humor, empathy, deception, responsiveness to social cues, and distinguishing pretend from reality (Hayes et al., 2001, McHugh et al., 2004; McHugh, Barnes-Holmes, Barnes-Holmes, Stewart & Dymond, 2007; Weil et al., 2011).

A new account of the development of perspective-taking, among other repertoires, has offered new avenues of research into the development of social behavior, namely for people with an ASD (McHugh et al., 2004). More recent frameworks (e.g., RFT) differed from earlier endeavors (e.g., ToM) in that teaching did not focus on simply training children to identify the emotions and informational states of others (Baron-Cohen, 1995; Howlin et al., 1999; Baron-Cohen, 2000). Rather, an RFT approach targeted the specific environment arrangements of stimuli in which social behavior emerged (Hayes et al., 2001; McHugh et al., 2004). A lack of attention to the social environment was a substantial limitation to early attempts to the analyze social behavior (e.g, ToM), as neglecting the influence of contextual (e.g., environmental) cues would surely limit the situations in which social behavior might occur or even if intervention (e.g., ToM) would generalize to everyday social behavior at all (McHugh et al., 2004; Weil et al., 2011). For example, an intervention program utilizing the ToM approach would focus on identifying the informational states of a peer based on their facial expression or affect of an individual while an approach targeting relational responding approach would involve referencing the current environment as the cues for an appropriate response in that given moment (Howlin et al., 1999). Within a ToM approach, knowledge of an informational state should theoretically allow the individual to predict how that person will behavior based on an inferred informational state (e.g., he is smiling, he is happy and we should keep playing). However, a ToM approach is inherently limited by the fact that inferred hypothetical informational states that may or may not be accurate for others. It does not reference the environment (e.g., location, context, etc.), the specific response to perform (e.g., a wave vs. a handshake) or what the consequences for that specific response may be (e.g., certain responses may not produce reinforcement in certain contexts). For these reasons, the incorporation of environmental factors (e.g., arrangements of antecedent stimuli and consequences for behavior) into an account of perspective-taking permits a more robust account of factors that might better explain the lacking and inconsistent improvements endorsed in ToM outcomes (Steerneman et al., 1996; Silver & Oakes, 2001; Klin, 2000; Fisher & Happe, 2005; Golan & Baron-Cohen, 2006; Gevers et al., 2006; Beeger et al., 2011; Gould et al., 2011). Continued improvements upon methods to both analyze and teach complex social behavior, not limited to perspective-taking, would likely offer benefits to children with ASD, mild developmental disabilities and even schizophrenia (Baron-Cohen, 1995; Baron-Cohen et al., 2000; McHugh et al., 2004; McHugh et al., 2007; Villate, Monestès, McHugh, Freixa i Baqué, & Loas, 2011).

Until just recently, relatively few behavior analysts have pursued research into teaching complex social repertoires to children with ASD falling under ToM (LeBlanc et al., 2003; McHugh et al., 2004, Rehfeldt et al., 2007; Weil et al., 2011). Among the main behavior analytic journals (e.g., the Journal of Applied Behavior Analysis and the Journal of the Experimental Analysis of Behavior), there has only been one study (LeBlanc et al., 2003) that targeted ToM specifically with a behavior analytic package. This lack of interest in ToM as a guiding framework for behavior analytic research is not surprising; as the assumptions for ToM and developmental psychology attribute the acquisition of behavior to neurological development rather than a specific type of learning history or teaching (Baron-Cohen et al., 2000; McHugh et al., 2004; McHugh et al., 2007). Furthermore, intervening upon behavior as measured and guided by an explanatory construct is something most behavior analytic researcher have not traditionally explored (De Los Reyes & Kazdin, 2006). Beyond measurement concerns, a lack of attention to environmental factors and an individual's personal learning history has limited the capabilities of researchers to design and research specific evidence-based teaching protocols for complex social behavior, including perspective-taking.

Research that has focused on the environmental factors that give rise to social behavior has produced a range of evidence-based procedures. In the area of social skills instruction and communication, well-established behavior analytic procedures exist for teaching turn-taking, greetings, commenting, reciprocal play, and a range of other discrete skills necessary for everyday human interaction (Koegel et al., 1999). However, children with ASD and other developmental disabilities can acquire these discrete skills but still demonstrate little variability in their behavior across people, settings and contexts (Koegel et al., 1999). Per a RFT account, it is possible that many of these individuals respond to the formal characteristics of stimuli in the environment (e.g., specific persons, features, etc.) but fail to respond to the informal, and less apparent, characteristics of stimuli (Hayes et al., 2001). Responses to informal relations from the arrangement of stimuli (e.g., front or back, top or bottom), rather than their formal (e.g., red or blue, full vs. empty) characteristics, can be considered a relational frame (Hayes et al., 2001). Responses to a relational frame involve correctly identifying these "informal" (e.g., not visible) relations between stimuli and responding to them accordingly (e.g., a relational response). Individuals who have not yet developed relational responding, to the point where it can be considered arbitrarily applicable (e.g., or utilized regardless of a specific context), likely respond to stimuli uniformly even when specific arrangements call for differential (e.g., relational) of responding (Hayes et al., 2001). Failures to acquire this type of repertoire may account for some of the instances of rigid behavior observed in clinical populations (e.g., performing one skill in one context but not in another) (Hayes et al., 2001).

Individual with ASD demonstrate difficulties acquiring a range of complex (e.g., relational) abilities. These types of responding (e.g., relational responding) refer to instances where the individual responds to a stimulus or event in terms of another stimulus or event (Rehfeldt & Barnes-Holmes, 2009). Among the common deficits in these populations one such example is in the use of pronouns, which may be utilized inaccurately between contexts in ASD and related disorders (Fay, 1979; Baron-Cohen, 1997). Pronouns, which rely on deictic relational responding (e.g., relations between the self and others), require that a speaker reference the gender of another person or object being referenced (Hayes at al., 2001). If the relational responding necessary to distinguish how the self relates to others, terms such as “he”, “she”, “him” and “her” may be utilized at inappropriate times or inaccurate situations (e.g., using the word “he” when referencing boys and girls). Learners with ASD have difficulty acquiring related forms of relational responding as well. Learners who fail to acquire deictic relational responding are also likely to have difficulty discriminating position (e.g., left vs. right relations), logic and reasoning (e.g., more vs. less relations), orientation (e.g., front vs. back relations), and even temporal relations (e.g., right now vs. a later time) (Hayes et al., 2001). Learners who are unable to respond to the informal relations between stimuli (e.g., a larger or smaller than relation) are much more likely to respond to the more apparent absolute characteristics of those stimuli (e.g., color, shape, etc.), which are readily apparent, without substantial training (Hayes et al., 2001). Without training specific to these relations, these types of repertories are unlikely to be fully established in individuals diagnosed with an ASD or a related developmental disorder. A failure to correctly derive and respond to these informal relations is thought to account for some of the overall deficits in generative communication and social reciprocity commonly seen in individuals with ASD (Rehfeldt et al., 2007; Hyman et al., 2009).

Behaviorism and Complex Human Repertoires

In recent years, behavioral psychology has re-approached analyses of complex human repertoires with renewed interest. A great deal of this newfound curiosity emerged following the introduction of Relational Frame Theory. Relational Frame Theory, or RFT, was developed as an extension of Skinner's Verbal Behavior into human language and cognition (Hayes et al., 2001). This approach grew from long-established behavior analytic principles and procedures (e.g., stimulus equivalence and rule-governed behavior), and extended an environmental account of behavior into the realm of complex and abstract abilities, including perspective-taking (Hayes et al., 2001). In accordance with RFT, complex abilities emerge as a result of developing relational repertoires- abilities to respond to informal and unseen relations between stimuli. Within these complex abilities, forms of relational responding thought to emerge individually, each the result of a separate history of multiple exemplar training and differential reinforcement (Barnes, 1994; Hayes, 2001).

As per a Relational Frame Theory account of complex behavior, an organism comes to demonstrate relational responding in response to a relational frame (e.g., an arrangement of stimuli). A relational frame is arrangement of stimuli that specifies a specific type of relation (e.g., a larger-than relation from a smaller and a larger object being positioned aside on another). After an organism can respond to relational frames, they can then respond to both the formal (e.g., observable physical characteristics) and informal (e.g., bigger-than, relational characteristics) properties of stimuli within the current context (Barnes, 1994; Hayes et al., 2001). When the organism is able to respond to both the formal and informal relations with a range of stimuli and in a range of environments, this type of behavior is considered "overarching" or arbitrarily applicable. To be arbitrarily applicable means that a particular response may emerge within completely different situations (e.g., structured school settings and unstructured social situations) or stimuli (e.g., larger-smaller relations with toys and with persons), akin to generalized conditioned repertoires (i.e. generalized imitation). The RFT approach holds that many forms of complex behavior (e.g., decision-making, perspective-taking, etc.) involve the coordination of ranges of relational responding, with each type of relational response the product of its own extensive learning history (e.g., larger-smaller, Here-There, I-You, etc.) (Hayes et al., 2001). Continued refinement on and integration of these forms of responding come to support the development of complex, flexible behavior (Hayes, 2001).

Derived Relational Responding

Complex behavior in Relational Frame Theory is interpreted in terms of the relational responding (e.g., response to relational frames) necessary to perform that type of behavior. Complex human responses, such as reasoning and logic, can be explained in terms of accurately responding to relational frames. In the case of logical reasoning, if given a context where A is related in some way to B (i.e. $A > B$) and B is in some way related to C (i.e. $B > C$), then a verbally-able individual should be able to derive (i.e. reason) that C is in some way related to A (i.e. $C < A$) and A is related to C in a different way (i.e. $A > C$). In this example, the individual demonstrates "reasoning" when they correctly label the relations between two previously stated stimuli without being directly referenced. When an individual can correctly respond to relations that have not been taught directly, this is referred to as a derived relational response (e.g., relations are "seen" though not physically visible). In an RFT account of behavior, complex behavior that occurs in completely novel contexts takes place through a process of derived relational responding, a long change of responses to relational frames. Through this process, it is likely that relational responding (e.g., responses to these relational frames) are types of learned behavior refined through exposure to reinforcement (Hayes et al., 2001). Beyond reasoning and logic, “framing” (e.g., responding to relational frames) has been identified in humor, empathy, distinguishing pretend from reality, and responding the social cues as well (Weil et al., 2011; Villadarga, 2009). It is hypothesized the highly complex and flexible human behavior is the product of many forms of relational responding and that more refined repertoires are necessary for more complex forms of behavior. One specific type of relational frame, deictic frames (e.g., relations between the “self” and others), are of significance taking the perspective of another (Dymond & Barnes, 1995; Hayes, Fox, Gifford, Wilson, Barnes-Holmes, & Healy, 2001). Deictic framing (e.g., correctly responding to relational frames of deictics) hold promise as a framework for operationally defining the types of skills necessary to assume the perspective of something other than themselves. Through continued teaching and shaping of such a repertoire, an individual may come to demonstrate additional generative behavior (e.g., actively derived relational responding) based on both the formal and informal properties of stimuli as they occur in the current context.

Beginning with Stimulus Equivalence

Relational Frame Theory emerged from the well-supported principles of stimulus equivalence (Hayes et al., 2001). Stimulus equivalence is an account of the procedures by which organisms come to understand how stimuli are related to one another (Sidman, 1971). These types of relations may come about either through direct training or by untaught derivations. Relations between stimuli were defined similarly to the mathematical relations of reflexivity, symmetry and transitivity. An equivalent relation would require that reflexivity, symmetry and transitivity be demonstrated (Sidman, 1971; Sidman, 1994; Barnes-Holmes et al., 2004). At the most basic level, reflexivity refers to instances where a stimulus refers to itself. Similar to "identity matching", reflexivity may come to relate one stimulus being directly related to another (e.g., if "Billy" then orient to Billy). Symmetry builds from reflexivity, establishing that relations occur in both directions. For example, if "Billy" is spoken then we look to Billy and if we orient to Billy then we say "Billy." The relation of similarity should occur regardless of whichever comes first (e.g., "Billy" is related to Billy and Billy is related to "Billy"). Transitivity emerges when relations form without directly instructing them. In the previous examples, relations are established through a history of reinforcement and conditional discrimination (e.g., correct responding produces reinforcement). Transitivity, in contrast, is the formation of relations that are not directly trained. For example, a transitivity relation may form when a symmetric relation between the spoken word Billy (A) and the boy "Billy" (B) and a symmetric relation between the spoken word "Billy" (A) and the written word "B-I-L-L-Y" (C) are established. The transitive relation would be between B and C, the relation was never formally taught. This relation would be that the boy Billy is related to the written word "B-I-L-L-Y", had a transitive relation been formed. Though first utilized in teaching for students with developmentally disabilities, stimulus equivalence provided a behavioral basis for nearly all of the everyday correspondences between words and stimuli in the environment, communication and interaction, and rules and the contingencies for following those rules (Sidman, 1994; Barnes, 1994; Barnes-Holmes et al., 2004).

Relational Frame Theory and Extending Stimulus Equivalence

The contributions granted by stimulus equivalence had enormous influence on modern behaviorism and the extensive applications for teaching that followed (Barnes-Holmes et al., 1994). Relational Frame Theory extended stimulus equivalence to better account for how humans come to derive stimulus relations even when stimuli are unrelated among formal (e.g., physical) dimensions, or *arbitrary* (Barnes, 1994). Through an increasingly rich history of differential reinforcement, the behavior of "relating" stimuli may itself be discriminated (e.g., if this object is related to this one, that one must be related to this one). The primary departure from stimulus equivalence is that behavior, including "relating", can come under antecedent or consequential control (Barnes, 1994). From this point, RFT posited that specific types of relational responding are under the control of antecedents and consequences. Beyond "similarity", the primary relation explained in stimulus equivalence, a wider range of relational patterns could be explained by RFT (Barnes, 1994). Beyond similarity, referred to as "coordination" in RFT, related patterns included "opposition" or opposite, "distinction" or different, "comparison", "hierarchy", "temporarility", "spatial", "conditionality/causality" or "deictic" (Hayes, 2001). Rather the procedures rigidly defined in stimulus equivalence, the patterns defined in RFT were non-reflexive, asymmetrical, transitive, and connected at the same time (Hayes et al, 2001).

In order to account for the non-reflexive nature derived relational responding, the procedures defined in stimulus equivalence had to be extended. The terms of mutual entailment, combinatorial entailment, and transformation of stimulus function were developed to extend upon reflexivity, symmetry and transitivity. The first term to be introduced was mutual entailment, which extended symmetrical equivalence relations. Such an extension was necessary, since arbitrary relations between stimuli may be bidirectional but not symmetrical. For example, in a frame of comparison where stimulus A is "greater" than stimulus B the shared relation would be that A is "greater" than B and that B is "lesser" than A. Mutual entailment refers to a bi-directional, shared relation (e.g., comparison includes a greater and a lesser). Per symmetry in stimulus equivalence the relation would be fixed and equal from A to B and B to A (e.g., A is "greater" than B and B is "lesser" than A). These types of relations are shared, flexible, and at the same time fixed (Hayes et al., 2001). Portrayed in formulae, mutual entailment holds that in a given context (C_{rel}), stimulus A is in some way (e.g., greater) to stimulus B, R_x. As a result stimulus B is now related in a related way to stimulus A, R_y, in that context. For example, in a teaching context (C_{rel}), the number 5 (A) is greater (R_y) than the number 3 (B). The shared relation in this context, separated by the ||| symbol, is that the number 3 (B) is also lesser (R_x) than the number 5 (A) in the same context. Presented in formulaic terms, this example of mutual entailment is presented below.

$$C_{rel} \{A\ R_x\ B\ |||\ B\ R_y\ A\}$$

or

In a counting task… {5 "greater than" 3 AND 3 "Lesser than" 5}

Beyond mutual entailment, which was an extension to symmetry, a term had to be developed for instances when behavior emerged from two previously established relations. The term combinatorial entailment was developed to account for the phenomenon of transitivity in equivalence relations, namely when novel relations emerged between multiple current relations. Spoken in formulae, combinatorial entailment occurs when in a given context (C_{rel}), if A is related (R_x) in some way to B and B is related (R_y) in some way to C, a range of relations would be derived ($A_{Rp}C$ and $C_{Rq}A$). As a result of this, A is in some way related (R_p) to C and C is in some way related (R_q) to A. For example, in a racing context (C_{rel}), Andrew (A) is faster (R_x) than Billy (B) and Billy (B) is faster (R_y) than Chris (C). The combinatorially entailed responses would be Andrew (A) is faster (R_p) than Chris (C) and that Chris (C) is slower (R_q) than Andrew

(A). In this example of entailment, a bidirectional relation was derived from two current mutually entailed relations (e.g., two faster/slower relations). It is important to note however, when these new relations are derived, the results may be much less precise than the original relations (Hayes et al., 2001). Presented in formulaic terms, combinatiorial entailment is presented below.

$$C_{rel} \{ A_{Rx} B \text{ and } B_{Ry} C \ ||| \ A_{Rp} C \text{ and } C_{Rq} A \}$$

or

In a race {Andrew "is faster than" Billy and Billy "is faster than" Chris

AND

Andrew "is faster than" Chris and Chris "is slower than" Andrew}

Aside from extending the procedurally-defined components of stimulus equivalence, a completely new term had to be introduced to account for instance when members of a current relation come to acquire the effects of another relation in some way (Hayes et al., 2001). Hayes and other RFT researchers claimed that when some stimuli in a relational network have certain psychological functions (e.g., fear), the functions of other relations in that network may come to be altered in accordance with these newly acquired relations. Put more simply, a transformation of stimulus function refers to instances where newly acquired stimulus relations have cascading effects on previously derived relations. This type of phenomenon was introduced to account for instances when a single relation (e.g., an "is alike to" comparison) can dramatically alter two or more networks of related stimuli. For example, if a very young child talking to their parent is told that their uncle is "like a snake" it is possible that the relations existing with a snake may transfer to the uncle. In this manner, the "like a snake" relation may lead the child to derive a sense of danger or fear to this individual (e.g., the uncle may bite me). Presented in formulae, the transformation of stimulus function (C_{func}) presents when the description that an individual is "like a snake" has transformative properties on the when a parent uses this description to describe another the child's uncle (C_{rel}). The description the uncle (A) "is like" a snake (B) has a transformative effect on the relations that the uncle (B) "is related" to the child (C). As a result of this transformation, the earlier relations between the uncle (B) and child (C) may come to be that the child (B) may be "harmed by" the uncle (C). As with the other forms of entailment, derived relations are less accurate as they extend beyond the initial context (Hayes et al., 2001). This is evident in this example, since the uncle is unlikely to bite or harm the child. Presented in formulaic terms, a transformation of stimulus function is presented below.

$$C_{func}\ [C_{rel}\ \{A\ _{Rx}\ B \text{ and } B\ _{Ry}\ C\ \{A^{f1}\ |||\ B^{f2}{}_{Rp} \text{ and } C^{f3}{}_{Rq}\ \}\ \}]$$

Or

WHEN told that the Uncle is LIKE a snake

WHILE talking to parents

Uncle (A) is "related to" Child (B) and Child (B) is "fearful of" Snake (C)

THEN Child (B) is "fearful of" Uncle (C) AND Uncle (C) "feared by" Child (B)

This formula holds that, in the presence of a current context cue, that an uncle is like a snake (C_{rel}), and a transformation of stimulus functions occurs for the uncle (A^{f1}) and the child (B^{f2}) and the snake (C^{f3}) are altered based on the basis of their previous relations (Hayes et al., 2001). For example, the uncle has now acquired relations of similarity to the snake. The child may then derive a wide range of relations to the uncle that consist of danger, poisoning, being bitten, etc. These widespread changes are denoted by an “f”, as changes are transferred throughout a network of relations rather than to a single relation (Hayes et al., 2001). These types of cascading changes have also been observed when transferring reinforcing functions to a network of equivalence classes (e.g., relational networks) (Hayes, Brownstein, Devany, Kohlenberg & Shelby, 1987), discriminating functions to a network of equivalence classes (Hayes, Kohlenberg, & Hayes, 1991), conditioned emotional responses (e.g., fear, as in the previous example) to members of equivalence classes (Dougher, Auguston, Markham, Greenway, & Wulfert, 1994), extinction functions (Dougher et al., 1994), and even self-discrimination within a relational network (Dymond and Barnes, 1994).

Many types of widespread changes within or between relational networks can be considered a transfer of stimulus functions. As stated in the earlier review of stimulus equivalence and RFT, equivalence relations are the result of frames of coordination (e.g., “is the same as”) and transfers of stimulus function reflect the changes that result when equivalence relations acquire a different relation (e.g., “is opposed to”). These types of widespread changes result from cascading relational changes beyond this change in relation. In an experiment by Dymond, Roche, Forsyth, Whelan and Rhoden (2007) nine adults were taught to demonstrate frames of coordination (e.g., X “is like” Y) and opposition (e.g., X “opposes” Y) in a computer-based relational teaching procedure. Once all participants demonstrated accurate relational responding to abstract symbols and figures, the experimenters paired select symbols and figures to either an aversive or pleasing sound. Following several presentations of these select figures followed by an aversive sound, all participants demonstrated widespread changes in their responding to related figures (e.g., whether figures were the same or opposite to the stimuli with aversive sounds). In this demonstration, the addition of a new relation to a specific stimulus (e.g., the stimulus followed by an aversive tone) produced differential responding in all the other stimuli that were related to that stimulus, whether it was the same or opposite (e.g., either a frame of coordination or opposition).

As transformations can be considered an extension of multiple instances of combinatorial entailment, transformations of stimulus relations may also produce relations that are much less precise than those originally directly trained (Hayes et al., 2001). For example, young children may attempt to insert toys that closely resemble food or snacks into their mouths. In this example, prior learning that food can be eaten and that food has specific shapes forms the basis of a relational network. In this example, the shape of a banana is distinct and yellow bananas are typically edible. However, upon biting into a toy with the shape of a banana that is not edible (e.g., plastic) a verbally-able child should form the relation that this toy is not edible. Transformations of stimulus function should then take place in all other corresponding relations between foods, toys and the other shapes that are similar to then (e.g., shapes of lemons, oranges, etc.) but are made of plastic (Hayes et al., 2001).

Families of Relational Frames

Relational frames are a special class of arbitrarily applicable relational responding. These types of responding are arbitrarily applicable in that the arrangement of any type of stimulus (e.g., object, event, person, etc.) may possess a certain relation (e.g., one person can be bigger than another and one event may be larger than another). These are demonstrations of mutual entailment, combinatorial entailment and transformations of stimulus functions. In this sense, relational "framing" are operant behavior, even though it is often referred to as a noun (Hayes et al., 2001). Relational frames are considered to be operant behavior for four reasons: they tend to develop over time, they have flexibility in their topography, they are under antecedent control, and they are also be under consequent control (Hayes et al., 2001). As operant types of behavior, they should be sensitive to training and experience and are limited only by availability of the verbal community and of the listener. For example, in a study by Lipkens, Hayes, and Hayes (1993) a typically developing child was able to derive mutual entailment relations as early as 16 months and could derive naming relations based on frames of difference. For example, these types of arbitrarily applicable relational responding demonstrate flexibility in that they the relations between stimuli are changeable, and even when initially formed, may change in part or whole based on conditions in the current context (e.g., through transformations of stimulus function). Lastly, this type of behavior is sensitive to antecedent and consequential control (Hayes et al., 2001). These relations are shaped responses to the current context as well as the events that follow in that given context.

Despite common features between types of relational frames, several families of relational frames have been identified as distinct in the literature. Typically, frames are best described as defining a relation of coordination, opposition, distinction, comparison, hierarchy, temporality, spatial, condition or causality, or deictic (Hayes et al., 2001). Frames of coordination can be described as having a relation of sameness or similarity (i.e. a name and a referent stimulus). For example, the picture of Billy is "the same as" the person Billy. Frames of opposition are defined as having an opposing relation along a similar continuum (i.e. cold and hot). An example of a frame of opposition could be the boy Billy and a toy for young girls (e.g., a doll). As a result of training, an opposing relation between Billy and the young doll may form (e.g., opposes predictions or earlier relations). A frame of distinction refers to a discriminant response in relation to related responses (i.e. this is not what I want). It does not directly specify either a “correct” or “incorrect” but references a difference from other stimuli. Akin to a relational form of discrimination, distinction occurs when a member of a relational network is derived as different. For example, in a relational network between a mother and two daughters a relational network of coordination exists for the female gender but a frame of distinction exists for the mother, who differs in age. Frames of comparison are involved in a range of context when responding to either a quantitative (more-less) or qualitative (better-worse) relation between stimuli (or networks of stimuli). Often seen in mathematics, a frame of comparison could take place when a teacher asks a student which contain holds more fluid. Assuming this repertoire is in place, the child would determine which container contains the greater volume. Frames of hierarchy extend from frames of comparison in that a certain stimulus may be viewed as different from related others (e.g., either subordinate, superordinate, or a member). While this frame has similarities to comparison relations, frames of hierarchy refer to one stimulus being an “attribute of” some other stimulus (or relational network of stimuli). In these types of frames, they often present when responding to relations involving categories or to stimuli that are only a part of a whole. For example, a child sorting a pile of toys into piles of animals from vehicles involves responding to a frame of hierarchy. Certain stimuli possess attributes of separate categories, which specify where each stimulus would be better grouped. Temporal relational frames are also similar to comparative frames, though they focus on a continuum of time. Given that changes in time are always unidirectional and that time cannot be observed (e.g., much different from ordering stimuli by their size). The ability to determine the ordering of stimuli without a physical reference point is a more abstract response that tends to emerge after developing the more fundamental frames. One example of a temporal relational frame is the ordering of steps in a recipe or a multi-step task. Spatial relational frames involve responding the physical arrangements of objects, or some aspect of objects (e.g., location), as the related to one another is space. An example of spatial relational frames could be identifying whether one stimulus is in front or behind another. In this relational response, the physical arrangement of stimuli is referenced. These types of frames are often referenced in a range of positional language including propositions and can take the form of in-out, front-back, over-under, top-bottom, and so forth. Frames of conditionality (and causality) share features from frames of hierarchical and comparative relations. In these types of frames, there may be a hierarchical ordering of stimuli that leads to a causal relationship. In these instances, a sequence of events (e.g., Billy puts ball on shelf, ball rolls down shelf, ball breaks pot) can be framed as a hierarchical sequence (e.g., each step is related to the proceeding). In a frame of causality, the listener may derive that the first step (e.g., putting ball on shelf) "causes" the final step (e.g., pot is broken) which is a hierarchical arrangement of cause and effect relationships. Lastly, the final family of frames involve the relations that represent stimuli in terms of the speaker and listener. These types of relations are representative of perspective, as relations with stimuli in the environment differ from individual to individual. These types of frames include, but are not limited to discriminations between Left vs. Right, I vs. You (Barnes & Roche, 1997), Here vs. There, Now vs. Then, Front vs. Back, Above vs. Below, and so on (Barnes and Roche, 1997; Hayes, 1984). It is important to note that many frames of deictic relations may involve frames of spatial relations, though the reference to the individual is the defining aspect of this responding.

Frames of Deictics

Deictic frames are thought to be pivotal for a variety of complex human behavior, including perspective-taking (Dymond & Barnes, 1995; Hayes et al., 2001; Roche, Barnes-Holmes, Smeets, Barnes-Holmes, & McGeady, 2000; Steel & Hayes, 1991). Deictic relations consist of the relational responding that differentiates a speaker from someone, or some stimulus, in current, past, or future environmen ating to the “self”, these types of language are unique and abstract in that the often represent relations specific to a single individual. These terms are abstract in that they only occur relative to the individual referenced (e.g., “my” or “your” are terms that cannot be interchanged). Individuals with difficulty acquiring relational responding may have particular difficulty with this form of responding due to this, as teaching trials for prepositions and pronouns cannot be modeled directly (e.g., we cannot correct an improper use of the word “my” by our saying “my”). For example, teaching a child to state “my cup” may have to be corrected by saying “no, this is your cup.” Many of the relational characteristics to pronouns involve significant complexity, which converges with evidence that these types of language take many years to develop (Fay, 1979; Baron-Cohen, 1997). In these types of responding, the relations between the individual referenced and the current environment serve as the cues for behavior in this instance.

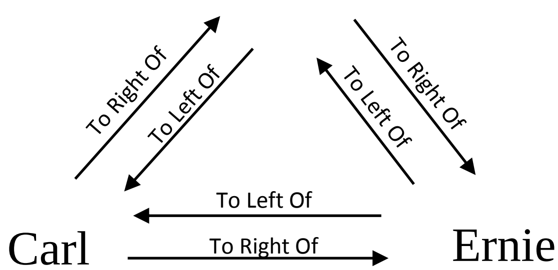


Figure 3. Sample deictic frame

Relational responding to frames of deictics are thought to form as a result of responding to queries and situations regarding the “self.” Some common examples that emerge throughout early childhood are “What are *you* doing *now*”, “What did *you* do *then*”, “What are *you* doing *here*”, “What are *you* doing *there*”, “What am I doing *now*”, “What did I do *then*”, “What am I doing *here*”, and “What will I do *there*” (Hayes et al., 2001). Through a complex learning history, the individual should correctly discriminate relations between him or herself in their use of language. An individual with a weak or absent repertoire for deictic responding would not be able to demonstrate relational discriminations between him or herself and others and may often misuse terms (e.g., pronouns) when they reference themselves or others. This is of particular relevance to individuals with ASD, who frequently have difficulty with aspects of language that have these characteristics (Fay, 1979; Barnes-Holmes, 1997). This difficulty with language and relational discriminations would likely impact their performance in social situations, as well. A failure to demonstrate this complex form of responding would likely resemble the deficits observed in ASD on traditional measures of Theory of Mind (Baron-Cohen, 1997). These individuals may demonstrate some degree of accuracy on measures of relational complexity, but nearly always fail to demonstrate proficiency at the greatest levels of complexity (Baron-Cohen et al., 1995).

Basic research on families of relational frames has helped to re-conceptualize a range of complex human repertoires. With a foundation in the principles of Verbal Behavior, complex and abstract human abilities can be analyzed and understood in the context of an individual learning history. Important human abilities, such as joint attention, have been studied through such a lens (Holth, 2005). Recent research has yielded new and novel accounts of complex human development and relational learning (Peláez, 2009). In recent years, a Relational Frame Theory account has provided new and novel ways to both conceptualize and teach naming (Miguel & Petursdottir, 2009), to teach spelling and reading, (de Souza, de Rose, & Demeniconi, 2009), to enhance procedures for teaching functional communication (Rosales & Rehfeldt, 2009), to teach empathy (Valdivia-Salas, Luciano, Gutierrerz-Martinez, & Visdomine, 2009) and mathematic skills (Ninness, Holland, McCuller, Rumph, Ninness, & McGinty, 2009).

Deictic Framing

The relational framing approach utilizes behavioral methods and teaching principles that extend from long-established basic research (Hayes et al., 2001). Within this type of approach, researchers and educators can develop an environmental account of how an individual comes to respond to stimuli in the environment as they relate to themselves and other features of the current context. At the most basic level, an individual should be able to correctly respond to frames of “I and YOU”, “HERE and THERE”, and “NOW and THEN” (Hayes et al., 2001). For instance, when asked the question, these three types framing, deictic frames, form the basis for deriving the relations that define an individual’s perspective as it relates to something, or somebody, in the current context. This complex type of behavior is thought to occur after many years of responding to deictic framing of various complexities in constantly changing contexts (McHugh et al., 2004; McHugh et al, 2007). Additionally, deictic framing poses an additional challenge to learners in relation to other types of framing. These frames always differ with respect to the stimulus (e.g., person, object, event, etc.) being referenced (I vs. YOU frame), the current location of reference (HERE vs. THERE frame), and current or past observations or descriptions (NOW vs. THEN frame). Deictic frames are unique among the families of relational frames, they can be demonstrated or modeled, but cannot be taught exclusively based on the formal characteristics (e.g., static colors, places, times, etc.) of the stimuli of reference (Weil et al., 2011).

This complex relational responding needed to take the perspective of another is thought to emerge through a long history of multiple exemplar training and reinforcement from the natural environment (Hayes, 1984). Through a long history of responding to various types of questions, and deriving various relations, to questions such as “What are YOU doing HERE?” or

“What am I doing NOW?” provides instances that shape more accurate types of responding and further introduce this type of responding the new and novel contexts (home, schools, informal social situations, etc.). As previously discussed in Weil et al., (2011) the linguistic structure of these types of statements could remain nearly indistinguishable in terms of their written form or selection of words, but the continuously physical environment and an individual’s continuously changing physical history ensures variability from one instance of framing to the next. In a more concrete sense, the specific words being used in the statements are not as important as the appropriate relational response performed in response to them and the current context.

More recently, basic studies on deictic framing have become more prevalent, with some researchers attempting applied research with them as well. One protocol, to be referred to as the “Barnes-Holmes Protocol”, was developed as a method for measuring and tracking an individual’s accuracy in responding to various relational frames and supplied context (McHugh et al., 2004). These original writers developed this technology in order to determine how individuals come to develop this type of framing in response to the varying types of complexities inherent in typical conversation. At the most basic level (e.g., simple relations) individuals were asked to respond to a single, isolated instance of a deictic frame. For example, an instance of a simple relation involving “I vs. YOU” the experimenter would state “If I (the speaker) have a blue block and YOU (the listener) have a red block” and then ask “Which block do I have? Which block do YOU have?” In this specific instance, a context was supplied as it related to I (the speaker) and YOU (the listener) and the listener would derive those simple relations in response to the questions immediately following, as shown in *Figure 4*.

I (Speaker)	:	Blue Block
You (Listener)	:	Red Block
"Which block do I have"	:	?
"Which block do YOU have"	:	?

Figure 4. Simple I and YOU frames

For an instance of a "HERE and THERE" frame, the experimenter would supply a context such as "I (the speaker) am sitting HERE on the red chair and YOU are sitting THERE on the blue chair." The experimenter would then ask "Where am I (the speaker) sitting? Where are YOU (the listener) sitting?" Responses to this type of frame consist of deriving locations with respect to the speaker and the listener, as shown in *Figure 5*.

"I (Speaker) am sitting HERE"	:	Red Chair
"YOU (Listener) are sitting THERE"	:	Blue Chair
"Where am I sitting"	:	?
"Where are YOU sitting"	:	?

Figure 5. Simple HERE and THERE frames

In the case of "NOW and THEN" frames, a context would be supplied that indicated two separate events separated by a temporal difference. For example, the experimenter could supply a context such as "Yesterday we were in the sandbox, but today we are on the swings" and then query "What were YOU doing THEN? What are YOU doing NOW?" As previously stated, a temporal relation is specified in this frame and the context is defined by the relations between the individual and their actions in time, as shown in *Figure 6.*

YOU (Speaker), THEN	:	Sandbox
YOU (Speaker), NOW	:	Swings
"What were YOU doing THEN"	:	?
"What are YOU doing NOW"	:	?

Figure 6. Simple NOW and THEN frames

As part of the complex nature of deictic relations, the references of I will always correspond with HERE and HERE will also always correspond with NOW. For example, to reference the self at the current point (e.g., the present or NOW) would require that the current location being referenced (e.g., HERE). For the speaker to reference themselves (a frame of I) with their current location (a frame of HERE), they also specify the current location in time as well (a frame of NOW), as shown in *Figure 7*.

"I (Speaker) am writing (HERE, NOW)"
"YOU (Listener) will be reading (THERE, THEN)"

Figure 7. Relation of I and HERE and YOU and THERE

After mastering the basic nature of deictic frames, increasingly complex contexts must be introduced to begin the difficult task of switching perspective (one or more members of the framing in a context). The designers of the Barnes-Holmes protocol introduced a second level (reversed relations) that included a single transformation of stimulus function (McHugh et al., 2004). A transformation of stimulus function establishes that the functions among these frames will differ beyond the single frames being switched. For example, the reversing of an I and YOU frame will also derive new relations with respect to HERE and THERE and NOW and THEN frames based on their original relation to the I and YOU frame. In the case of a reversed I and YOU frame one example would be "I have a green car and YOU have a red car" and "If I were YOU and YOU were ME; which car would I have? Which car would YOU have?" In this context, the I vs. YOU frame would reverse and the relations between referenced stimuli would change. In their response, the frame of I (the original listener) would then correspond with the *green car* and the frame of YOU (the original speaker) would correspond with the *red car*. The transfer of stimulus function in this case would refer to the reversing of the relations between and I and YOU and the resulting changes from altering the relations. Similarly transfers of stimulus relation occur for the HERE and THERE and the NOW and THEN frames as well, as shown in *Figure 8*.

"I (Speaker) have a green car"
"YOU (Speaker) have a red car"

"I (Speaker) have a green car"
"YOU (Listener) have a red car"

I (Speaker) : ?
YOU (Listener) : ?

Figure 8. Reversed I and YOU frame

Per the Barnes-Holmes protocol, the highest level of complexity involved two distinct transformations of stimulus function (double reversed relations). These two transfers occur between the I and YOU frame and either the HERE and THERE or NOW and THEN frames simultaneously. An example of an I and YOU and HERE and THEN reverse is "I (the speaker) am sitting HERE on the red chair and YOU (the listener) are sitting on the blue chair. If I was YOU and YOU were ME and if HERE was THERE, where would YOU (the listener) be sitting? Where would I (the speaker) be sitting?" In this context, two separate transfers must be made and the individual must derive the new relations in order to respond correctly. The I vs. YOU reversal alters the stimulus relations in this context and the HERE vs. THERE reversal alters these same stimulus relations again, as shown in *Figure 9*. Similarly, double reversals for the I and YOU and the NOW and THEN frame follow the set of steps necessary to derive new relations. These multiple reversals add increasing levels of complexity and aim to closer resemble the complexity of relational responding inherent in daily communication, as displayed in Table 2.

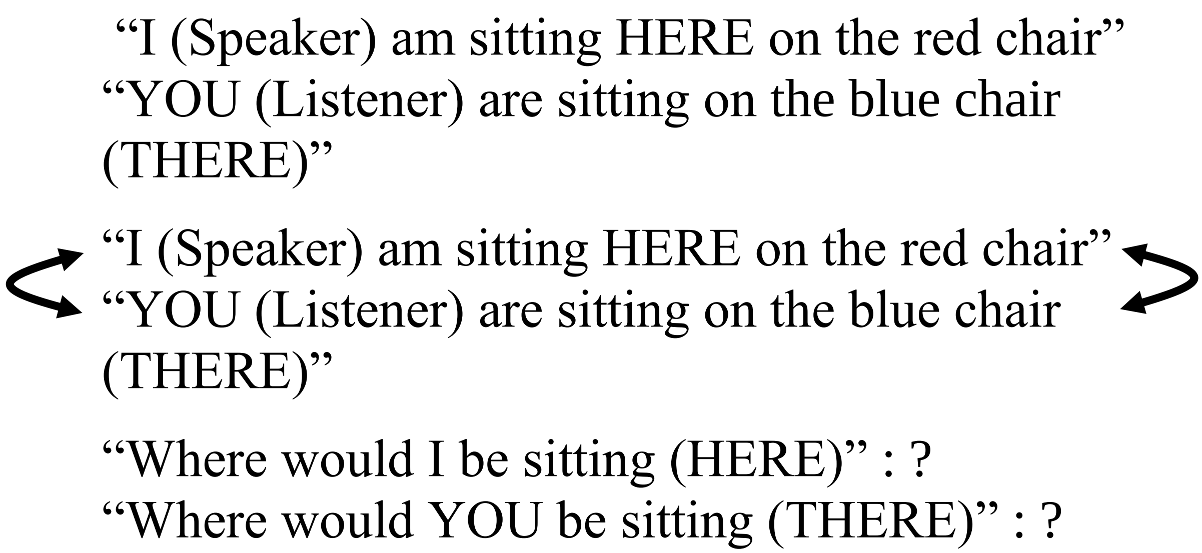


Figure 9. Double Reversed I and YOU and HERE and THERE

The Barnes-Holmes protocol has been used to assess the accuracy of relational responding for a variety of populations. A comparative study among various age groups (early childhood to late adult) found that (1) error rates will increase as the level of complexity becomes greater and (2) there are differential patterns of performances across age groups

(McHugh et al., 2004). Their findings indicated that mean percentages of errors for each levels of complexity decreased as a function of age into late adulthood. These findings were intriguing, with findings converging with traditional developmental research on this topic. Children in the early childhood age range (age 3-5) had the greatest amount of errors as compared to all other age ranges. The developmental literature predicts the emergence of Theory of Mind around six years at the earliest. However, given the linear trend demonstrated across age ranges, individuals likely develop this type of relational responding throughout a long exposure of multiple exemplar training and differential reinforcement in various contexts.

Table 2. Stages of Theory of Mind and degrees of relational complexity

Levels of Complexity	Theory of Mind Stages	Relational Complexity
I	Simple Visual Discriminations	I-You Framing
II	Complex Visual Discriminations	I-You Framing
III	"Seeing leads to Knowing" and forming belief	I-You and Now-Then Framing
IV	Prediction based on True Beliefs	I-You, Now-Then, and Here-There Framing
V	Inferring False Beliefs and predicting future false behavior	I-You, Now-Then, Here-There, and Logical-Not Framing

A deictic training protocol holds a great deal of potential as way for teaching relational repertoires to children and those with having some form of disability. Many of these phenomena align with the descriptive stages established in the current Theory of Mind literature (McHugh et al., 2004). For instance, the first two stages towards Theory of Mind refer to acquiring relational responding. More specifically, levels I & II refer to responding to deictic frames of I and YOU with varying levels of visual complexity. The third level extends from previous steps by incorporating a NOW and THEN relational frame (temporal relational responding). The addition of a NOW and THEN frame allows for the listener to derive the relations for future relations (i.e. a prediction). The fourth level introduces a HERE and THERE frame, incorporating I and YOU, HERE and THERE, and NOW and THEN frames which allows the listener to derive the perspective of another. Only when the listener can derive the relations between all of these frames can she or he come to derive the "true belief" of another and their future action (i.e. a prediction for THEN). At the fifth and final stage, additional complexity is introduced by adding a frame of LOGICAL and NOT to account for a false belief condition (i.e. IF X THEN not) (McHugh et al., 2006). The inclusion of a LOGICAL and NOT frame adds significant complexity, which is observed very commonly in the behavioral and developmental literature for individuals with developmental disabilities (McHugh et al., 2004) and even schizophrenia (Villatte et al., 2010). In the most recent studies, young children ages (5-7) were successfully taught to derive this form of relational responding (Davlin et al., 2011; McHugh et al., 2007; Weil et al., 2011). In the Weil et al., 2011 study, researchers effectively taught young children to derive relational responses and demonstrated Theory of Mind across all five levels after training. All participants were unable to pass these levels in baseline.

More recently, some of the developers of the initial Barnes-Holmes protocol have developed a more streamlined approach for teaching this type of responding (McHugh, Barnes-Holmes, & Barnes-Holmes, 2009). Polishing these forms of responding into a curricular sequence, an increasingly varying approach to teaching these relations lends to the assumption that these types of responding are refined through a combination of multiple exemplar training and differential reinforcement that occurs throughout many contexts. Over the gradual learning of these relations, and increasingly complexities, complex social behavior (i.e. perspective-taking) may come to occur in many types of social and personal contexts.

Frameworks for Perspective-Taking

The ability to take the perspective of another involves a substantial degree of difficulty. Beginning with the basic ability to determine that what one person sees and thinks is different from one other, perspective-taking extends well into deriving the covert and unseen forms of human behavior as well (Howlin et al.., 1999; McHugh et al., 2004). Within the Theory of Mind account, proponents of this theory highlight the importance of progressing through neurodevelopmental stages as the driving force in the development of these abilities (Baron-Cohen et al., 1985; Baron-Cohen, 1995; Baron-Cohen, 1997; Howlin et al., 1999; Baron-Cohen et al., 2000). These abilities are thought to be the product of biological maturation, with the establishment of these abilities occurring around age six (Taylor, 1988).

Theory of Mind and Perspective-taking

As stated earlier, a Theory of Mind is thought to follow a series of neurodevelopmental milestones. After a child has met all five milestones (e.g., stages) and can demonstrate the abilities to infer the beliefs of others they can be said to demonstrate a Theory of Mind (Baron-Cohen, 1995; Howlin et al., 1999; Baron-Cohen, 2000). At the first level, a child should be able to discriminate what they see from what another individual sees (Howlin et al., 1999; Weil et al., 2011). At this time in childhood, children begin to acquire the pronominal terms to refer to themselves and others differently. At this level, children should be able to correctly respond to queries for both what they themselves see and what others see (Howlin et al., 1999; Weil et al., 2011). For example, a child demonstrating this skill should be able to determine that two persons looking at opposing sides of a two-sided card should see something different. The child should correctly identify what they themselves see as opposed to what another individual sees.

For the second level of Theory of Mind, more complex visual discriminations are involved (Howlin et al., 1999). As an extension to the first level, more complex visual stimuli are referenced. For example, factors such as rotation are added to simulate different perspective (e.g., angles). In an analogue of this type of response, a child should be able to describe what they see and what another sees as before but with a rotated figure (e.g., a 'd' on one side and a 'p' on the other). An individual in this stage of development should be able to take the visual perspective of another with respect to angle and position.

At the third level of theory of mind, individuals should be able to demonstrate knowledge of how beliefs and other mental states are formed. Within this level of development, individuals should be able to identify why certain beliefs come to be. At this level of development, the individual should understand that "seeing" should then lead to "knowing" and the individuals should form beliefs based on their observations (Howlin et al., 1999; Weil et al., 2011). In such a task, the individual may be shown a small object (e.g., a candy) being placed into a small container. An experimenter would then ask the child where the candy was and how they could know. A child that has met the third stage of ToM development should understand that beliefs are the result of experience and describe the environmental events that form the basis of them (e.g., seeing a candy placed somewhere).

In the fourth level of ToM, individuals demonstrate the ability to identify the beliefs of others and made a prediction regarding how they might behave. Children at this stage should be able to infer the behavior of others based on their "true beliefs", which are beliefs that occurred based on true and factual events (e.g., events known to be true) (Howlin et al., 1999; Weil et al., 2011). Extending from the prior example, if the individual views another individual (or a doll) seeing a candy placed into a container, the individual should be able to identify the "true belief" (e.g., that the candy is believed to be in the container) and make a prediction for how the other individual might behave (e.g., would go back to the container later for candy).

The fifth and final stage in the ToM framework introduces “false belief”, instances when children have to predict how others behave on the basis of *incorrect* knowledge. More accurately, individual should be able to identify when they themselves possess correct beliefs and another possesses incorrect or “false beliefs.” Demonstrating this type of skill suggests that (1) an individual can discriminate between their own “true” beliefs and another’s “false” beliefs and (2) that their own beliefs are different from others. Analogues of this task extend from the previous example, with the exception that the item changes location without the other individual’s (e.g., doll’s) knowledge. This involves the child determining that the doll holds a “false” belief and will behave according to that false belief. Examples such as this form the basis of the Sally-Anne/False Contents task.

Progression through the stages of ToM is thought to be the result of biological maturation and neurological development (Baron-Cohen et al., 2000). Given the underlying developmental assumptions, perspective-taking is thought to be an innate human ability that does not require specific learning or environmental exposure (Baron-Cohen et al., 2000). In cases where perspective-taking does not emerge (e.g., ASD), many of social difficulties are assumed to be the result of genetic and biological defect and thus, intractable. As such, a ToM framework may not reveal specific environmental arrangements that may advance or slow the development of social behavior.

Relational Frame Theory and Perspective-taking

As indicated in the prior section, the ability to demonstrate perspective-taking involves substantial relational complexity. Per RFT, perspective-taking involves the coordination of a range of relational frames (e.g., deictic frames) that relate to the speaker/listener (e.g., the self/others). These frames involve the relations necessary to discriminate the self from the others (e.g., frame of I-YOU), one's own position from that of others (e.g., frame of HERE-THERE) and the current present from some other time (e.g., frame of NOW-THEN). Similar to the ToM framework, an RFT account of perspective-taking emphasizes increasing relational complexity. Per the RFT account, this type of repertoire is the product of exposure to the environment and to reinforcement. Complex repertoires such as perspective-taking require a range of complex and complicated prerequisite skills and are gradually shaped and improved over the lifetime (McHugh et al., 2004).

In a study surveying perspective-taking (e.g., deictic framing), McHugh et al. (2004) found that overall accuracy improved with age. These results contrasted an earlier presumption that perspective-taking abilities were innate and established by age six. Rather, the authors suggested that perspective-taking was related to increasing proficiency with relationally complex material. Through sampling how accurately individuals of varying ages respond to varying levels of deictic complexity, a trend of increasing proficiency was observed over time. The results of McHugh et al., (2004) support earlier conclusions that relational responding and complex repertoires consisting of relational responding (e.g., perspective-taking) are a form of operant and thus shaped through on-going exposure to the environment.

Rather than assuming that complex repertoires (e.g., perspective-taking) are the result of biological maturation, an RFT account of these abilities emphasizes the role of the environment and the context. Per an RFT account, increasingly complex relational responding is actively shaped by the verbal community in response to relational frames and differential reinforcement for their correct responding (McHugh et al., 2004). Through active shaping of these repertoires, increasingly complex behavior comes under more specific, and accurate, contextual control (Hayes et al., 2001).

As indicated earlier, proponents of ToM have identified several increasingly demanding levels of complexity that should be demonstrated before an individual is said to demonstrate knowledge of "false belief" and Theory of Mind (Baron-Cohen, 1995; Baron-Cohen, 2000). Given that performances on false beliefs tasks involves substantial complexity, it is not surprising that these skills do not emerge until later in childhood (Taylor, 1988). The major advantage to interpreting complex repertoires in terms of relational frames is that many complex repertoires (e.g., perspective-taking) can be linked to a specific learning history (Hayes et al., 2001).

Given supporting evidence that perspective-taking is likely dependent on relational responding (e.g., to deictic frames), many of the stages of ToM likely represent differential levels of relational complexity (McHugh et al., 2004; Weil et al., 2011). Referring back to the first level of ToM, a child should be able to discriminate between what they themselves see and what another individual sees (Howlin et al., 1999; Weil et al., 2011). This initial level is consistent with language acquisition in young childhood (Fay, 1979). At this time in childhood, children begin to acquire the pronominal terms to refer to themselves and others differently. For example, the terms "mine" and "yours" require relational responding with respect to the children themselves and others in the verbal community (e.g., an I vs. YOU deictic frame). At this very basic level, children demonstrating this type of relational responding should be able to correctly derive the relations between what they themselves see and what others might see (Howlin et al., 1999; Weil et al., 2011). An example of the responding characteristic of Level 1 ToM is provided in *Figure 10*.

Level 1 Theory of Mind
Card with Two Sides (One Red, One Blue)

C_{rel} {A Rx B ||| B Ry A}

OR

If on different sides { I see RED AND YOU see BLUE}

Figure 10. Level I theory of mind and relational framing

A relational frame approach to perspective-taking extends well-beyond the most basic forms of visual discrimination (Hayes et al., 2001; McHugh et al., 2004; Weil et al., 2011). Relational frames can also account for the relational responding necessary when more complex visual discriminations are necessary (Howlin et al., 1999; Weil et al., 2011). As an extension to Level 1, at this stage more complex visual stimuli are referenced and deictic frames of I vs. YOU and HERE vs. THERE become more related to contextual cues (e.g., positioning). As stated in previous examples, stimuli with either reversed or rotated pairs of visual information are a good example (e.g., ‘d’ on one side and ‘p’ on the other). In an example such as this, Level 2 ToM would reference a change in position (e.g., angle) in addition to the frame of I vs. YOU. An example of Level 2 ToM from an RFT account is provided in *Figure 11*.

Level 2 Theory of Mind

Two Sided (One with ‘p’, One with ‘d’)

$$C_{rel} \{ A\ _{Rx}\ B \text{ and } B\ _{Ry}\ C\ ||| \ A\ _{Rp}\ C \text{ and } C\ _{Rq}\ A \}$$

OR

If on different sides {

I am HERE and HERE has not rotated the ‘d’

AND

YOU am THERE and THERE has rotated the ‘d’

}

Figure 11. Level II theory of mind and relational framing

As observed above, the complexity of relational responding can be accounted for by additional levels of framing involved. Additional contextual factors such as positioning (e.g., including HERE vs. THERE deictic frame) require the derivation of additional relations (e.g., I vs. YOU as well as HERE vs. THERE relations) (Hayes et al., 2001; Weil et al., 2011). Given that the levels of ToM are marked by increasing relational complexity, an RFT account is able to identify specific frames involved as well as how relations are framed from the environment. The same progression can be identified for the Level 3 of ToM, where children identify an informational state of another (Baron-Cohen, 2001; Hayes et al., 2001; Weil et al., 2011). For an individual to determine the informational state of another (e.g., thoughts, feelings, knowledge, etc.), this type of response requires that the individual determine that after one sees, then one knows (e.g., NOW vs. THEN) (Howlin et al., 1999; Weil et al., 2011). For example, a false-contents or Sally-Anne task involves determining an individual’s beliefs based on an observation. For a relational frame account of Level 3 ToM, if the individual (e.g., I) observes an event from their location (e.g., HERE) something not known will be known afterwards (e.g., NOW vs. THEN). In an example such as this, the addition of the deictic frame of NOW vs. THEN permits the individual to derive an informational state for another individual (e.g., I vs. YOU) in the correct location (e.g., HERE vs. THERE) and time (e.g., NOW vs. THEN). An example of Level 3 ToM from an RFT account is provided in *Figure 12*.

Level 3 Theory of Mind

Empty Container

$$C_{rel}\ \{\ A\ _{Rx}\ B \text{ and } B\ _{Ry}\ C\ |||\ A\ _{Rp}\ C \text{ and } C\ _{Rq}\ A\ \}$$

OR

If looking to an empty container being filled {

I am HERE and NOW there is no candy HERE

THEN

I am HERE and THEN there is candy HERE }

Figure 12. Level III theory of mind and relational framing

Increasing degrees of relational complex continue towards the fourth level of ToM, predictions of behavior based on the "true beliefs" of another individual (Howlin et al., 1999; Weil et al., 2011). At this level, deriving these relations is thought to be an indicator of a child's ability to determine informational states within another individual (Howlin et al., 1999). In this stage, additional complexity is introduced the relational responding demonstrated in Level 3 ToM becomes derived for another individual.

A RFT account of this level of ToM holds that an individual will be able to derive the informational states of another individual, through a transformation of stimulus function. For example, additional relations are formed on the basis that perspective is “switched” (e.g., “if I were you”, etc.). This transformation results in cascading changes throughout the relations derived, assuming the relations for the other individual referenced (Hayes et al., 2001). A figure demonstrating this transformation of stimulus function is displayed in *Figure 13.*

Level 4 Theory of Mind

True Beliefs

$$C_{func}\ [C_{rel}\ \{A\ _{Rx}\ B \text{ and } B\ _{Ry}\ C\ \{A^{f1}\ |||\ B^{f2}{}_{Rp} \text{ and } C^{f3}{}_{Rq}\ \}\ \}]$$

OR

If YOU and I were switched [

You are reading a book by bed and I am eating in the kitchen {

I am HERE (in the kitchen) and NOW (eating)

AND

YOU are THERE (in the bedroom) and NOW (reading)

BECOMES

YOU are HERE (in the kitchen) and NOW (eating)

AND

I am THERE (in the bedroom) and NOW (reading)

}]

Resulting Changes

Figure 13. Level IV theory of mind and relational framing

The final stage in the ToM framework presents with even greater degrees of complexity, the inclusion of “false belief” into predictions of how another may respond (Howlin et al., 1999; McHugh et al., 2006; Weil et al., 2011). Including falsehood into relational responding has been theorized as a Logical-Not relational frame (Hayes et al., 2001; Weil et al., 2011). The Logical-Not frame is akin to the relation of Correct vs. Incorrect (Hayes et al., 2001; Weil et al., 2011). False belief is considered another transformation of stimulus functions. As the individual derives the relations when taking perspective, an additional frame of Logical-Not should produce another transformation of stimulus function throughout the network on those previously derived beliefs being false (Hayes et al., 2001; Weil et al., 2011), as shown in *Figure 14*.

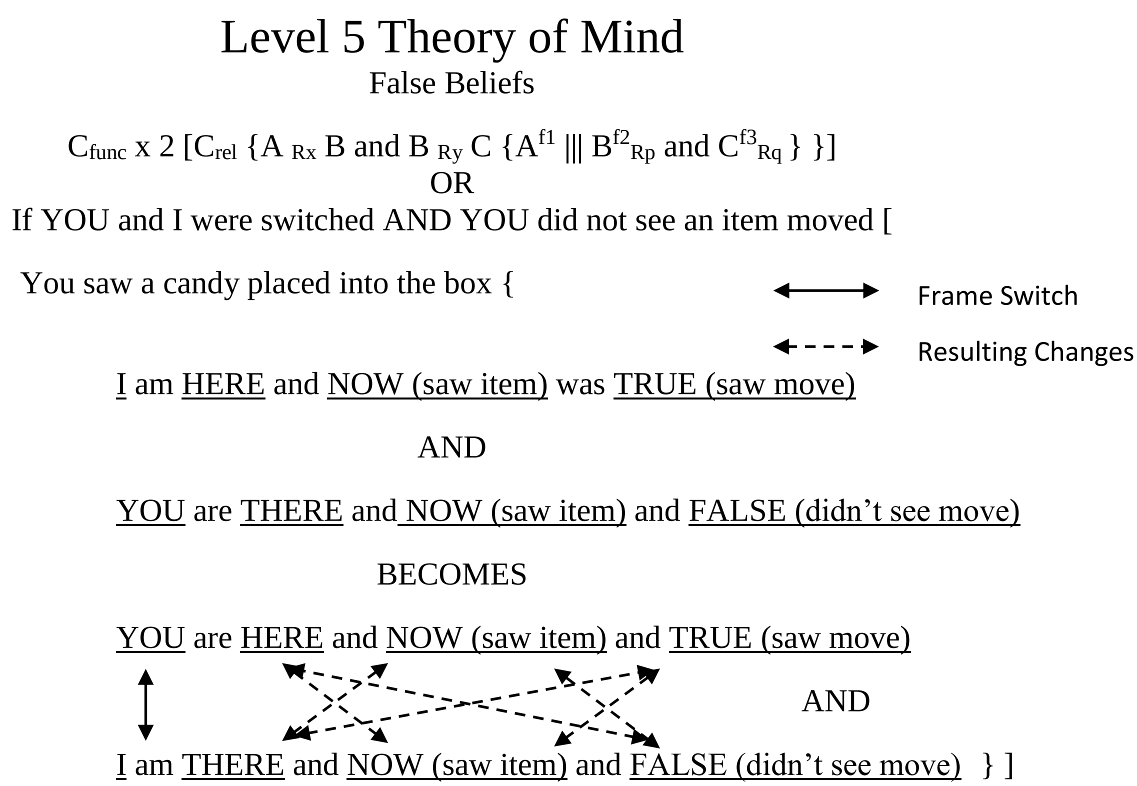


Figure 14. Level V theory of mind and relational framing

Within an RFT account of perspective-taking, increasingly complex relational responding can be interpreted in terms of the amount of relations that must be formed (Hayes et al., 2001; McHugh et al., 2004; McHugh et al., 2006; Weil et al., 2011). Interestingly, this increasing level of complexity maps closely to many of the descriptive milestones for ToM (McHugh et al., 2004; Weil et al., 2011). As indicated in the RFT account of ToM levels, increasingly complex "switches" (e.g., a change of perspective by individual relational frame) level is marked by substantial changes throughout the relational network (Hayes et al., 2011).

Revisiting the Assumptions Underlying Theory of Mind

The development of Relational Frame Theory has permitted new ways to conceptualize how complex repertoires are formed (Hayes et al., 2001; McHugh et al., 2004; McHugh et al., 2006; Weil et al., 2011). Of the many benefits to this new and competing theory, those offering an environmental account of these abilities may better inform remediation or provide novel intervention altogether (Rehfeldt et al., 2007). In fact, the re-evaluation of these complex repertoires likely suggest that the development of contextually-sensitive relational repertoires encompasses much more than biological maturation (McHugh et al., 2004; McHugh et al,. 2007; Rehfeldt et al., 2007). These types of repertoires may themselves be a stronger and more valid measure of social behavior than earlier tests (e.g., tests "true" and "false" beliefs). In the randomly-controlled studies of ToM, improvements on tests of ToM (e.g., the Sally Anne task) were observed without any corresponding improvements in social behavior (Silver & Oakes, 2001; Fisher & Happe, 2005; Golan & Baron-Cohen, 2006; Beeger et al., 2011). Given that ToM measures themselves may not be representative of social behavior at all, an environmentally-driven and contextually-sensitive framework (e.g., relational responding) may be a much more robust and valid indicator of complex behavior.

Acquisition of Relational Responding

At present, several researchers have adapted several protocols for training children to demonstrate relational responding to deictic frames (e.g., perspective-taking) (McHugh et al., 2004; Rehfeldt et al., 2007; Davlin et al., 2011; Weil et al., 2011). All of these protocols were based on the Barnes-Holmes protocol, which assessed deictic framing skills and provided a framework for individuals to practice deriving stimulus relations. Participants were trained to identify the contents of individual frames (e.g., "simple framing"), to switch single frame and identify the resulting changes and to switch two frames and identify the changes that resulted (McHugh et al., 2004; McHugh et al., 2006; McHugh et al., 2007). Training individuals to correctly identify the contents of relational frames (e.g., Simple Frames), to correctly identify relations when one frame was switched (e.g., Reversed Frames) and to correctly identify relations when two frames were switched (e.g., Double Reversed Frames) corresponds to Levels 1-3, 4 and 5 respectively (per an RFT account of perspective-taking) (McHugh et al., 2004; Weil et al., 2011). Through training individuals to correctly respond to transformations of stimulus function across all types of deictic frames (e.g., I vs. YOU, HERE vs. THERE, NOW vs. THEN), deictic framing repertoires improved across all levels of complexity.

The Barnes-Holmes protocol has been successful used in computer-based instruction (McHugh et al., 2004; Rehfeldt et al., 2007), storytelling activities (Davlin et al., 2011) and traditional table-top activities (Weil et al., 2011). The results of these studies have indicated that training children to respond to deictic frames (e.g., derive frames of ranging complexity) has strongly indicated that children can improve their accuracy on a range of relationally complex tasks (e.g., the Barnes-Holmes protocol).

Evidence for Teaching Deictic Frames

The Barnes-Holmes protocol was successful for teaching a range of typically developing children and adolescents to demonstrate highly accurate relational responding across a range of deictic complexity (e.g., Deictic Framing). This protocol has been incorporated into a range of computer-, tabletop- and story-time teaching approaches. The computer-based protocol was used to successfully to teach typically-developing children to respond to deictic frames across all three levels of complexity (e.g., Simple, Reversed and Double Reversed Frames) (McHugh et al., 2004; Heagle et al., 2006; Rehfeldt et al., 2007). The tabletop-based extension of the Barnes-Holmes teaching protocol was used to successfully teach young children (e.g., 4- and 5-year olds) how to respond to all levels of deictic complexity (Weil et al., 2011). Interestingly, results of the Weil et al., (2011) study indicated that all students successful passed tests of Theory of Mind following successful training on the teaching protocol. In a more naturalistic approach to delivering a teaching protocol, Davlin et al., (2011) trained three children (aged 5-7 years) to correctly respond to varying levels of deictic complexity using a storybook reading activity to deliver instruction.

Teaching Deictic Frames and Autism Spectrum Disorder

Despite a high degree of applicability for using deictic frames and Relational Frame Theory as a framework for intervening on social behavior, only one study has been published on deictic frames and ASD (Rehfeldt et al., 2007). The Rehfeldt et al. (2007) study was the only experiment to introduce a computer-based protocol to children with a disability (high-functioning ASD). These researchers utilized the Barnes-Holmes protocol as a framework for intervention on relational responding deficits. Though progress was less dramatic than typically-developing counterparts, children diagnosed with high-functioning autism could be taught to correctly respond to deictic frames. Beyond this conclusion, this study was the first to find that children with an autism spectrum disorder demonstrated greater difficulty as relational complexity increased. More specifically, children with ASD had greater difficulty when the situation called from one or more transformations of stimulus function (e.g., Reversed and Double Reversed relations).

A Pilot for Teaching Perspective-taking to Children with Autism Spectrum Disorders

As indicated in the previous section, extensions of a teaching protocol for deictic frames in ASD have been relatively limited (Rehfeldt et al., 2007). Given that an RFT approach to complex behavior (e.g., perspective-taking) could better inform how these repertoires emerge, additional validation and support is necessary. Prior to this study, a pilot was conducted to investigate the effectiveness of teaching children diagnosed with ASD to correctly respond to relational frames.

Participants

The participants in this study were three children with an earlier diagnosis of autism. These children were currently enrolled in a range of school settings, aged 8, 9, and 13 years old respectively, as shown in Table 3. All children were offered participation through their local schools and all research trials occurred in their homes, after their typical school day. Four participants met criteria for screening though one student could not commit to the intervention due to scheduling constraints.

Materials and Setting

The pilot was conducted using a multiple probe design. The multiple probe design is appropriate for evaluating the impact of instruction on earlier and later components of a skill sequence (Cooper, Heron, & Heward, 2007). The multiple probe design also limits threats to internal validity, such as practice effects and satiation, and unnecessarily long baseline conditions without a reinforcement condition (Horner & Baer, 1978). Treatment integrity checklists were completed for every trial and agreement was conducted by a trained graduate student in school psychology.

Table 3. Participants in initial deictic framing pilot

Participant	Age	Sex	Autism Spectrum Disorder	Educational Services
Andrew	8	Male	Yes	Reading and Social Skills Programming
Brian	9	Male	Yes	Reading, Mathematics and Social Skills Programming
Charles	13	Male	Yes	Social Skills Programming
Dylan	11	Male	Yes	Mathematics and Social Skills Programming

Dependent Measures

The dependent measures used for the pilot were overall accuracy of responses to deictic frames. Accuracy was measured by levels of difficulty (e.g., Simple, Reversed, Double Reversed) as well as overall total aggregated accuracy (e.g., overall average). Dependent measures were computed for each session. Sessions ranged in length from 15 to 25 minutes and no more than two sessions were completed in a single afternoon.

Teaching Protocol for Deictic Frames

Teaching procedures for the study were based on those used by Davlin et al., (2011). The presentation of each probe (e.g., teaching session), the format of the probe and error correction procedures were kept constant from the Davlin et al., (2011) study. The probe presented in each session was kept consistent with the structure of the Davlin et al., (2011) protocol. For each session, individuals were presented with 15 simple relations, 11 reversed relations and 11 double reversed relations, as shown in Table 4. As a departure from the typical computer-based teaching protocols for deictic frames, the Davlin protocol introduced relational frame trials within the context of the children's story being read at the time. For example, probes using children's stories used the context of the current reading (e.g., I vs. CHARACTER) as a more interesting and age-appropriate counterpart to traditional approaches (e.g., I vs. YOU). A different children's story was used for each probe session.

Table 4. Levels of deictic complexity

Framing Level	**# Frames**	**# Switches**	**Example**
Simple	15	0	Buzz Lightyear is flying in the air. You are in the dining room. Where is Buzz? Where are you? (No frame switch)
Reversed	11	1	You are reading a book. Pongo is playing with the puppies. If you were Pongo and Pongo were you, what would you be doing? If Pongo were you and you were Pongo, what would Pongo be doing? (One I & You frame switch)
Double Reversed	11	2	Right now you are reading, you were playing on the computer before. Goofy is celebrating a birthday right now, he was cleaning the house before. If you were Goofy and now was then, what would you be doing? If Goofy were you and then was now, what would Goofy be doing? (One I & You and one Now & Then frame switches)

Interobserver Agreement

Trained observers provided interobserver agreement for 33% of all sessions. Trained observers were graduate students enrolled in a School Psychology PhD program. Average observer agreement was 95% with a range of 80-100%.

Baseline Procedures

Probes for baseline conditions remained separate from the stories and measures used in training phases. All participants began with an initial probe for all levels of relational complexity (e.g., Simple, Reversed, Double Reversed). Following the initial probe, the student with the lowest rates of responding participated in at least three consecutive points until steady state responding was observed. No other participants completed a baseline probe until training conditions began. No error correction procedure was in place for baseline conditions.

Training and Maintenance Procedures

Each training session contained the same probe structure as baseline sessions, but with an error correction and reinforcement procedure. Error correction procedure consisted of representing the trial until the participant responded correctly. Reinforcement procedures consisted of a “beat your score” approach, with access to items from an early in-vivo preference assessment following the session contingent on equal or greater performance than the previous session. Criteria for mastery in the training phase was three consecutive sessions with greater than 80% overall accuracy. Once participants met criteria for mastery, a maintenance condition was introduced. Procedures in maintenance were identical to those of the baseline phase.

Generalization Procedures

In following by training on all levels of deictic complexity and a final probe for generalization to a novel adult. The adult used was a completely novel graduate student who agreed to present trials. The procedures for the generalization probe were identical to that of baseline, with the exception that a novel adult delivered the instruction.

Results

The results of this pilot indicated that all participants were able to successfully demonstrate relational responding across Simple, Reversed, and Double Reversed deictic frames. As illustrated below in *Figure 15*, all children demonstrated very low overall accuracy on each probe in baseline conditions and much higher levels of overall accuracy in training, maintenance

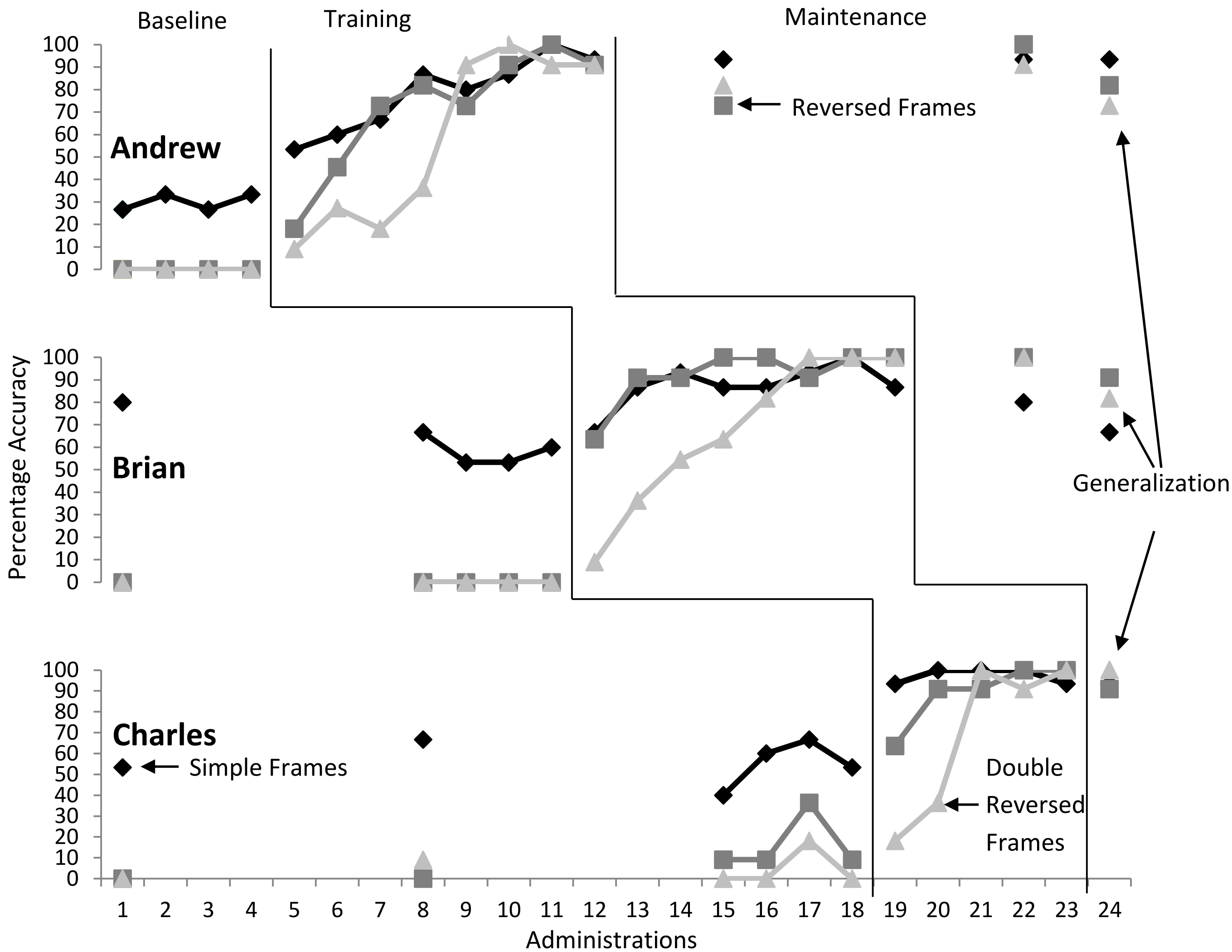


Figure 15. Results of deictic training pilot

and generalization probes. Additionally, each child demonstrated generalization of relational framing repertoires to a novel adult examiner in follow up (*see Figure 15*). Consistent with the previous study (Davlin et al., 2011) and others (Rehfeldt et al., 2007; Weil et al., 2011), children acquired simple frames before reversed and reversed before double reversed.

In addition to high levels of effectiveness, measures of intervention acceptability on the Intervention Rating Profile-15 (IRP-15) were high as well. High rating ratings on the IRP-15 suggested that parents found the intervention to both appropriate and socially valid for perspective-taking and for children with autism (Martens, Witt, Elliott, & Darveaux, 1985), as shown in Table 5.

Table 5. Results of IRP-15 for pilot study

Item	**Average Score**	**Range of Scores (1-6)**
1. This would be an acceptable intervention for a child's problem behavior.	5	5-5
2. Most teachers would find this intervention appropriate for behavior problems in addition to the one described.	5	5-5
3. This intervention should prove effective in changing a child's problem behavior.	5	5-5
4. I would suggest this intervention to other teachers.	5	5-5
5. The child's behavior is severe enough to warrant the use of this intervention.	5	5-5
6. Most teachers would find this intervention suitable for the problem behavior described.	5	5-5
7. I would be willing to use this intervention in the classroom setting.	5	5-5
8. This intervention would not result in negative side effects for the child.	5	5-5
9. This intervention would be appropriate for a variety of children.	4.67	4-6
10. This intervention is consistent with those I have used in classroom settings.	5	5-5
11. The intervention was a fair way to handle the child's problem behavior.	5	5-5
12. This intervention is reasonable for the problem behavior described.	5	5-5
13. I liked the procedures used in this intervention.	5	5-5
14. This intervention is a good way to handle this child's behavior.	5	5-5
15. Overall, this intervention would be beneficial for a child.	5	5-5

Discussion

The results of this study further support that learners with ASD can be taught to all forms of deictic frames. All participants demonstrated improvement from baseline to training, follow-up and generalization. The results of this analysis extended earlier research on ASD learners, namely in their differential performances on specific types of frames. For example, some participants demonstrated greater variability with respect to specific types of frames (e.g., some acquired HERE vs. THERE relations more quickly than NOW vs. THEN). Similar variability was observed between levels of complex as well, as each student demonstrated different rates of acquisition different levels of complexity.

This results of this study further support that individuals was ASD can be taught to demonstrate this type of relational responding following a specific learning history (e.g., Barnes-Holmes protocol). These findings are encouraging, as only one other study has previously demonstrated this type of learning in ASD (Rehfeldt et al., 2007). However, despite encouraging findings there are a variety of limitations that prohibit definitive conclusions. Most notably, the fact that this type of relational responding generalized to a novel adult may or may not mean that this type of responding would generalize to a same-aged peer-- or to a novel social context. In addition to this, tests of Theory of Mind did not occur in either the baseline or following training conditions. Future interventions should try to reproduce these findings and explore individual performances on Theory of Mind tasks, interactions with matched typical peers, and generalization to other children in more varied contexts.

Extending Support for Deictic Framing and Autism Spectrum Disorders

While the promise of a new approach assess and teach relational responding is encouraging, substantial research is necessary to further validate the Relational Frame Theory approach to complex behavior. The Relational Frame Theory approach has enjoyed considerable support in the area of Deictic Framing and perspective-taking in typical populations, both young and old (McHugh et al., 2004; McHugh et al., 2007; Rehfeldt et al., 2007; Davlin et al., 2011; Weil et al., 2011). Further extensions this approach would benefit from work with the ASD population, as done so in Rehfeldt et al., (2007). At this time, both the results of Rehfeldt et al., (2007) and the current pilot study suggest that relational responding (e.g., responding to relational frames) can be taught to individuals with an ASD. A greater emphasis on the generalizability of these abilities and the delivery of such a method would be telling as well.

Including Technology in the treatment of Autism Spectrum Disorders

Given that a Relational Frame Theory account of perspective-taking emerged from computer-based methods, there may be additional opportunities for delivering such an intervention using technology. Referencing ASD specifically, computer and mobile technology has become an increasingly prevalent component of social skill intervention packages for ASD (Golan & Baron-Cohen, 2006; Grynszpan, Martin & Nadel, 2008; Reed & Hirst, 2011; Diehl, Schmitt, Villano & Crowell, 2012; Mintz, Branch, March & Lerman, 2012). In a relatively recent survey of the use of technology to teach social skills to children with autism by Reed & Hirst (2011), technology was has been used to teach a range of social skills including the initiation of a conversation, play skills, responding to others and a range of social communication. Interestingly, “mind-reading” and the ToM framework were adapted to use technology for teaching the identification of inferred mental states (Golan & Baron-Cohen, 2006). Despite a range of successful extensions of behavior analytic interventions to technology, as reviewed in Reed and Hirst (2011), the ToM approach was unsuccessful for generalizing skills beyond the teaching samples when delivered via computer (Golan & Baron-Cohen, 2006). Speaking more broadly, randomly controlled studies have suggested that practicing the identification of inferred mental states does not generalize altogether (Beeger et al., 2011). Given early evidence from our pilot study that training children to demonstrate relational responding did indeed generalize to individuals beyond the teaching trials, additional support is needed to validate the generalizability of deictic framing when using technology.

Including Peers in the treatment of Autism Spectrum Disorders

Among the many reasons why interventions such as ToM “mind-reading” might fail to generalize to novel social contexts, an exclusively adult-focused intervention may limit the degree to which social behavior emerges in novel contexts. For example, skills taught by adults to learners with ASD are unlikely to generalize to peers and other situations without direct training in the natural situation with their same-age peers (Pellechia & Hineline, 2007). This particular challenge is widely acknowledge and the inclusion of, or mediation by, same-age peers has been considered best practices in the area of social skill training (Koegel et al., 1997). Peer-mediated intervention programs have been very successful in the teaching and generalization of social skills (Chung, Reavis, Mosconi, Drewry, Matthews & Tasse, 2007; Wang, Cui & Parrila, 2011; Lorah, Gilroy & Hineline, 2014; Mason, Kamps, Turcotte, Cox, Feldmiller & Miller, 2014). Through peer-mediated strategies, intervention packages also enjoy fewer demands placed on adults (e.g., teachers, parents, etc.) as well as increased teaching opportunities in the natural situation with naturally occurring stimuli (e.g., typical peers) (Koegel et al., 1997). As a further extension of the literature on Deictic Framing, intervention could be developed in such a way that peers may be able to accurately and appropriately deliver training specific to relational responding.

Summary

Throughout the past decade, behavioral psychology has revisited a range of complex human behavior (e.g., perspective-taking) (Hayes et al., 2001). When viewed as derived relational responding (e.g., responses to deictic frames), repertories such as perspective-taking have been successfully linked to arrangements of environmental stimuli and individual learning histories (Hayes et al., 2001; McHugh et al., 2004; McHugh et al., 2007; Rehfeldt et al., 2007;

Davlin et al., 2011; Weil et al., 2011). The identification of learning histories the underpin repertoires such as perspective-taking contrasts earlier accounts of development, which highlighting the role of biological maturation in these abilities (Baron-Cohen, 1995; Howlin et al., 1999; Baron-Cohen-2001). Rather than biological maturation, complex human abilities are considered instances of derived relational responding in a Relational Frame Theory account of behavior (Hayes et al., 2001; McHugh et al., 2004). These types of abilities have been linked to a range of developmental sensitive milestones and developmental across the lifespan (McHugh et al., 2004; Weil et al., 2011). Repertoires such as perspective-taking are of particular importance for individuals with an ASD, as difficulties with perspective and relation social behavior are a hallmark feature of these disorders (Baron-Cohen et al., 2000; Hyman & Towbin, 2009; Scattone, 2007).

Relational Frame Theory and derived relational responding has since become a competing account of perspective-taking. Historically, the Theory of Mind approach has dominated research on perspective-taking in developmental psychology (Baron-Cohen. 1995). Where the RFT account highlighted environmental factors and learning histories, ToM emphasized biological maturation as the driving force behind the development of complex social behavior, including perspective-taking (Baron-Cohen et al., 2001; McHugh et al., 2004; Weil et al., 2011). However, recent developments have called the utility and generalizability of ToM approaches altogether (Beeger et al., 2011). Recent advances in an RFT account of perspective-taking have indicated the these repertoires can be taught (McHugh et al., 2007; Rehfeldt et al., 2007; Davlin et al., 2011; Weil et al., 2011) and improvements on measures of ToM were observed following training (Weil et al., 2011). Additionally, the results of a prior pilot indicate the presence of generalization beyond teaching examples. Approaches utilizing ToM have indicated very little-to-no generalization with traditional (Beeger et al., 2011) and computer-based delivery (Golan & Baron-Cohen, 2006).

The topic of the current study extends upon the literature for Deictic Frames and ASD. Building from an earlier pilot study, the methods in this demonstration will be completely peer-mediated through the development of customized mobile technology. Computer interfaces will be simplified, the size of the device will be decreased, data collection responsibilities will be automated and the delivery of error correction and reinforcement will be handled by the device. In addition to analyzing the effectiveness of peer-mediated Deictic Framing protocol, A RFT account of perspective-taking could be expanded through upon additional investigation of how increases on traditional test of ToM relate to accuracy of relational responding (e.g., Deictic Frames).

CHAPTER 3

METHODS

This study aimed to determine (a) whether a peer be trained to deliver simple, reversed, and double reversed instances of relational framing using technology, (b) the effects of instruction using reinforcement and feedback delivered via a mobile device on responding of children with ASD, and if (c) training on deictic framing result in improvements on traditional tests of Theory of Mind (Levels III-IV-V)?

Participant Screening

All participants received a diagnosis of autism and had a sufficient vocal repertoire. A sufficient vocal repertoire was considered to be the abilities to respond to wh- questions, answer short questions vocally, follow two- and three-step directions, and provide at least three word responses to questions. All participants read at or near grade level, consistent with the pilot study, though little reading (one to two simple words) was required to implement the intervention. Potential participants were considered based on teacher reports of substantial social difficulty. To be included in the study, each participant had to demonstrate deficits on one or more of the three levels of difficulty (Simple, Reversed, or Double Reversed) as well as deficits on traditional Theory of Mind probes. Each participant was screened to meet these criteria and all students demonstrated deficits in relational responding per deictic framing probes and Theory of Mind tasks.

Matched Peer Screening

In order to facilitate a peer-mediated intervention, a same-aged peer had to be selected from a target student’s classroom. The student that had to implement the intervention had to be able to read single or two-word answers as displayed on the teaching. The student did not have any marked impairment or skills deficit that interfered with their administration of the intervention. Due to scheduling and location constraints of the school setting, the fourth research participant (e.g., the non-ASD participant) served as the matched peer.

Participants

All students were recruited through offerings of research participation to local school districts. As presented in Table 5, three learners with an autism spectrum disorder and one additional non-ASD peer met criteria for inclusion. The average age was 10.5 years with a range of 10 to 11 years of age. All students had a history of difficulty with socialization and were fully included in a general education setting for the majority of the school day. As presented in Table 2, all participants were males and communicated using spoken language.

Andrew

Andrew was 11 years-old at the time of the study. He had received a diagnosis of autism from an outside professional upon his initial entry into public school. He was receiving resource room support for academic difficulties and general organization supports for mathematics, language arts, science and social studies. He received 60 minutes of resource room support per day with same-aged peers, who were with and without an autism spectrum disorder. Andrew demonstrated marked social difficulties, evidenced by frequent arguments, disagreements and general difficulty interacting with same-age peers. Andrew correctly responded to 18% of the trials during the initial deictic framing protocol, suggesting a deficit in relational responding and perspective-taking. Andrew correctly responded to 27% of trials on the initial theory of mind probe.

Brian

Brian was a 10 year old male receiving academic support in all academic settings. Brian had a diagnosis of autism from an outside professional following his entry into elementary school. Brian demonstrated less overt social deficits, with his primary challenges being the formation and sustaining of age-appropriate social relationships. Brian correctly responded to 15% of the trials during the initial deictic framing protocol, suggesting a deficit in relational responding and perspective-taking. Brian correctly responded to 38% of trials on the initial theory of mind probe.

Carl

Carl was an 11 year old male receiving pull-out academic support for math, language arts, science and social studies. He received 60 minutes of support daily in a group of his same-age peers. Carl had received a diagnosis of autism following his entry into elementary school. He demonstrated significant deficits in social situations, which had historically escalated to tantrums and the use of physical force. Carl correctly responded to 18% of the trials during the initial deictic framing protocol, suggesting a deficit in relational responding and perspective-taking. Carl correctly responded to 38% of trials on the initial theory of mind probe.

David

David was a 10 year old male receiving academic support in math and science in a pull out resource setting. David had received a diagnosis of Attention Deficit Hyperactivity Disorder and did not have a diagnosis of autism. David was included due to his marked difficulty with socialization. He received 60 minutes of academic support in math and language arts daily, additional time on tests and shortened and clarified instructions. David demonstrated some deficits in social behavior, though to a much lesser degree than the others in the study. He correctly responded to 57% of the trials during the initial deictic framing protocol, suggesting a deficit in relational responding and perspective-taking. David correctly responded to 50% of trials on the initial theory of mind probe. Though participating in the study as well, David served as the matched peer for the other students while the other students served as the matched peer of David.

Materials and Setting

All training sessions were conducted in the students' classroom following their completion of assigned tasks for the resource period. The teaching occurred in the corner of the classroom, with two students seated in separate desks facing one another. Session length varied with respect to the level of difficulty being training, though no probes took more than 5-10

Table 6. Peer-mediated Deictic Framing Participants

Participant	**Age**	**Sex**	**Autism Spectrum Disorder**	**Educational Services**
Andrew	11	Male	Yes	Accommodations in Math, Social Studies and Science
Brian	10	Male	Yes	Accommodations in Math, Social Studies, and Science
Carl	11	Male	Yes	Accommodations in Math, Social Studies, and Science
David	10	Male	No	Individualized resource support as needed

minutes to deliver. All computer trials were presented to students diagnosed with an Autism Spectrum Disorder by David, the matched peer who did not have a diagnosis of autism spectrum disorder.

Dependent Measures

Throughout all phases of the study, the dependent measures were the accuracy of responses to deictic frames with one, two or zero switches in perspective and the traditional measures of Theory of Mind. As participants met criteria for mastering Reversed and Double Reversed frames, participants were administered frames at all levels of difficulty and traditional ToM tasks. This occurred at specific points throughout the study. Theory of mind tasks were based on those used in Weil et al., (2011).

Perspective-taking Protocol

As noted earlier, the previously successful replication of the Davlin et al., 2011 methods was adapted to be delivered through a custom developed game based on Barnes-Holmes protocol. The intervention was delivered in the context of a peer-mediated game between a matched student and a target student with autism. The protocol was “read” by the matched student by way of their pressing a button on the display of the tablet computer. In doing so, the content was read to the target student via TextToSpeech methods. To prevent the potential for satiation and ratio strain, the amount of trials were reduced from the initial pilot study. Simple relation probes reduced the amount of trials from 15 to 7 (2 I vs. YOU, 2 HERE vs. THERE, and 3 NOW vs. THEN). Reversed relation probes reduced from 11 to 7 (2 I vs. YOU, 2 HERE vs. THERE, and 3 NOW vs. THEN) and double reversed probes reduced from 11 to 6 (2 I vs. YOU/HERE vs. THERE and 4 I vs. YOU/NOW vs. THEN). Through pre-defined mastery criteria, teaching sessions were selected by the device and levels of instructional difficulty increased over time (e.g., more complex relational content) as accuracy improved.

Theory of Mind Measures

In addition to measures of relational complexity, learners with autism were administered probes to determine their performances on traditional measures of Theory of Mind. More specifically, these analogues were developed around levels III, IV and V from the Theory of Mind framework (Weil et al., 2011). An individual who can appropriately complete the level IV task should be able to identify the "true belief" of another and correct responding on the level V task should indicate that the listener can identify the "false belief" of another individual. The measures for this study were identical to those used in the 2011 Weil et al. experiments, which were adapted from the Howlin et al. (1990) study. Levels III, IV, and V were tested at baseline, upon meeting criteria for reversed relations, and after meeting criteria for double reversed relations. For level III measures, the target student should be able to derive that an individual's seeing an event leads to "knowing." For this experiment, a student (with either a doll or action figure) will be shown an examiner placing objects into a container. The student will then be asked what they think is in the container and why. Similarly, the child will then be asked what the doll (or action figure) thinks is in the container. Consistent with Weil et al. (2011), six questions will be provided for this level of complexity.

For the level IV tasks, the child was introduced to a similar context but with more elaborate questions asked from the doll/figure's perspective. Weil et al. 2011 asked "Why would the doll think that the item is by the plane?", "where would the doll go to get the car?", and "Why will the doll go over to the plane?" These types of queries tap into the skills that determine "true beliefs" from the perspective of someone, or something, else. The correct responses to these questions would be because the doll (or action figure) had seen an event and now “knows” what they believe. Consistent with Weil et al. (2011), six questions were provided for this level of complexity. Lastly, level V tasks build from level IV but involve making predictions based on another’s belief of something incorrect (“false belief”). Knowledge of an individual’s incorrect beliefs is helpful for predicting how an individual might respond in that type of situation. In these instances, the child would be made known of a switch or change that could not have been observed by the other party (the doll or figure). A child demonstrating theory of mind should be able to predict, from the perspective of someone other, that this other individual would respond according to their own false beliefs. Consistent with Weil et al. (2011), six questions were provided for the final level of complexity. These probes were administered to all participants at baseline, following successful training on Reversed relations, and after successful training on Double Reversed relations.

Data Collectors, Instructors, and Procedural Fidelity

In order to determine agreement between the student instructing peers and their scoring of the accuracy of the participant responses the primary investigator was present during pre-test, training and maintenance conditions. This occurred for a total of 100% of all sessions. The participant running sessions was provided training with the primary investigator on how to correctly present trials and record responses. This student completed trial exercises with corrective feedback for three consecutive trials with 100% accuracy before they proceeded to run trials with others. In addition to training, a procedural fidelity checklist was used to ensure that all trials were correctly run for all sessions after training. Procedural fidelity checklists were completed for all sessions. Observer agreement for all sessions would be based on a comparison of the permanent product of the student operating the device (e.g. database entry) vs. on-going fidelity checks of the examiner (e.g. correct button was pressed). Theory of Mind measures were conducted by primary investigator, assisted by one of the students' teachers.

Interobserver Agreement

Interobserver agreement (IOA) data were collected for 100% of all trials in baseline, training and maintenance conditions for deictic material and 44% of all sessions for Theory of Mind tasks. IOA data were calculated by dividing the number of agreements by the number of agreements plus disagreements for both deictic content and ToM tasks. Observers for deictic content were the student teaching (e.g., device record) and the lead investigator and observers for ToM tasks were the lead investigator and a special education teacher. Agreement for deictic training probes was 97.29% (566 agreements, 12 disagreements) overall and agreement for theory of mind probes was 100% overall.

Experimental Design

A single subject multiple probe design was used for the study (Tawney & Gast, 1984). The training for each level of deictic framing complexity was presented in the order Simple, Reversed and then Double Reversed for all participants. A criteria of 80% overall accuracy for three consecutive probes was necessary prior to moving to the next portion of the study, a level consistent with earlier revisions of this protocol (Rehfeldt et al., 2007; Davlin et al., 2011; Weil et al., 2011). Progression from one level to another was automated by the device contingent on the user's performance. Through specific design, the child running an instructional session selected the student to be taught from a list of the current participants (e.g., by way of the student's username) and the specific contents, layouts and controllers for that that specific student would be loaded at the current level of difficulty. Visuals of the design and layout are included in the appendix of this study. These procedures were consistent throughout all levels of the intervention. Following the initial participant meeting criteria, one more participant began the initial trials and so on.

Baseline Procedures

Probes for baseline consisted of six simple frames (e.g., 2 I vs. YOU, 2 HERE vs. THERE, 2 NOW vs. THEN), seven reversed frames (e.g., 2 I vs. YOU, 2 HERE vs. THERE, 3 NOW vs. THEN) and five double reversed frames (e.g., 2 HERE vs. THERE, 3 NOW vs. THEN). In baseline conditions, the typical peer provided instruction as per the program's design by pressing the text to be read to the peer with an autism spectrum disorder. The color of the text would then switch to blue, indicating that the device is currently reading to the peer (who is wearing headphones). The text would fade to light grey upon successfully reading the full question to the target student. The matched peer would then press the next block of text to read, and so on. As the device provided questions to the target student, the correct answer to the frame was cast onto a green (correct) button and any other response was cast onto a red (incorrect) button. The specific location of the right answer alternated to minimize the likelihood that a participant could judge a correct or incorrect response by location. Through careful design, child teachers correctly administered items in order and mastery of the skill itself was not a prerequisite to teaching due to color coordination. As the peer teacher provided all instructions to the target peer and recorded their response, data were logged into an embedded SQLite database and the following trial was animated to the front of the device's display. Throughout all baseline conditions no feedback was given to the target peer. No game points or feedback (correct or incorrect noises) were provided for either correct or incorrect responding. All participants completed one baseline probe on average during each scheduled visit. The amount of visits during the week ranged from two to three throughout the entirety of the study.

Pre-test and baseline probes

Following with the previous design in the pilot study, participants completed at three points of baseline measurements before beginning the training protocol. In baseline conditions, neither the matched peer nor the tablet computer provided error correction or feedback. Baseline conditions continued under steady state responding was observed via visual analysis. Additional participants completed pre-test probes as earlier participants begin formal training.

Deictic Framing Probes

Training that targeted deictic framing was conducted in a multi-phase process, beginning with the most basic components (e.g. simple frames) and then systematically introducing one (reversed) and then two (double reversed) frame switches. These components were targeted individually to better understand the differential impact of this form of relational responding on traditional theory of mind tasks. It is possible that as students improve performance on increasingly complex relational responding, this repertoire may generalize to other similar types of complex responding (e.g. perspective-taking). Each teaching session consisted of a single type of relational complexity (e.g. reversed frames). In doing so, the amount of opportunities to respond in each session ranged from a minimum of 10 to a maximum of 14 opportunities to respond (e.g. two opportunities per frame). Given that the participants did not have to record responses manually, did not have to read or correct responses vocally and that the results of the trial were immediately calculated, few deviations from this preset design were likely to occur. A minimum of three training sessions were conducted for each participant in the training phases. Participants moved from simple frames to reversed frames following three consecutive instances of 80% of more accuracy on simple frames and from reversed frames to double reversed frames following three consecutive instances of 80% or more accuracy on reversed frames respectively.

The peer running trials followed the intervention protocol as it was designed on the tablet device. The specialized computer program on the Android tablet (7” model) delivered targeted feedback (i.e. pleasing tone when correct) and correction contingent on the target student’s performance on each task when properly administered by the peer running the device (i.e. an unfavorable tone followed by an error correction procedure). The computer software recorded all student performances, error corrections and timestamps of each administration. The project was developed using the free Java platform, the source of which is available upon request.

Treatment Procedures

Reinforcement

In order to maximize compliance and continued effort, each participant was presented with a short break between trials. Reinforcement was delivered via a range of aesthetically pleasing sound effects, the accumulation of points towards a personal cumulative high score, on-going self-charting and an overall ranking as compared to other peers. Points delivered during for correct responding phases were 10 for Simple Frames, 30 for Reversed Frames and 50 for Double Reversed Frames. All participants were provided with an- in-vivo preference assessment to rule out the possibility that these types of conditioned reinforcers were indeed preferred.

Error Correction

In order to provide on-going feedback, an error correction method was triggered whenever an incorrect response was identified. Responses were differentially reinforced through aesthetically-pleasing sound effects for correct responding and traditionally non-preferred sound effects (e.g. ‘buzzer’) for incorrect responding. During instances of incorrect responding, the device mediated the auditory feedback and the student running the trial initiated a method to deliver a vocal statement that prompted the correct response. It is important to note that the former method (e.g. auditory reinforcer) was mediated by the device and the latter (e.g. error correction) was mediated by the peer running the device. This was designed in order to allow the peer running the device to deliver feedback more than once, if requested of them.

Theory of Mind Probes

Throughout the study, Theory of Mind probes were administered at three different points throughout the intervention. All participants were administered Probes related to Levels III, IV, and V of Theory of Mind, as previously demonstrated in Weil et al., 2011. Theory of Mind probes were delivered prior to baseline phases (as inclusion criteria), following the mastery of Reversed Framing (mid-level difficulty) and following the mastery of Double Reversed Framing (high-level difficulty).

Deictic Framing Probes

Consistent with the earlier pilot study, learners completed a variety of deictic frames across varying levels of complexity. Following a steady baseline of at least three points, the pair began the use the computer program and to be exposed to differential reinforcement (via the tablet device) and programmed error correction procedures. The criterion for mastering the frames was 80% accuracy across three consecutive administrations for each level of complexity. Theory of Mind probes were delivered by the examiner at three times during the experiment: once in baseline, once following mastery of reversed framing, and once following the mastery of double reversed framing. The computer program displayed scripted prompts for the examiner and student responses were collected using the software as well.

CHAPTER 4

RESULTS

Andrew

Andrew's baseline, intervention and maintenance data for all levels of deictic framing are depicted in *Figure 16*. One point of baseline was collected for Simple frames, two points of data were collected for Reversed frames and three points of data were collected for Double Reversed frames. Baseline performance for Simple frames was 41.67% and average performances in Reversed and Double Reversed frames were averages of 35.71% (range: 14.28% - 57.14%) and 20% (range: 0% - 60%) respectively. Andrew met criteria for mastery for Simple, Reversed and Double Reversed framing with 3, 5, and 4 sessions respectively. Andrew maintained these gains in follow-up probes, with average accuracies in maintenance phases for Simple, Reversed and Double Reversed frames at 91.67% (range: 83.33% - 100%), 82.85% (range: 57.14% - 100%) and 80% (range: 60% - 100%) accuracies. In terms of visual analysis, the non-overlap between data in baseline and maintenance conditions indicates that the deictic training protocol produced improved rates of accuracy across all levels of framing difficulty. These gains persisted from training into maintenance conditions throughout the study.

Data indicating Andrew's performance on Theory of Mind measures in baseline, following mastery of deictic framing with a single switch (Reversed frames) and following mastery of deictic framing with two switches (Double Reversed frames) are displayed in *Figure 16*. The three Theory of Mind levels (III-V) assessed in baseline were 16.67%, 33.33% and 33.33% respectively, with an overall accuracy of 27.78% for the baseline probe. The Theory of Mind levels (III-V) assessed following mastery of Reversed framing were 33.33%, 33.33% and 33.33% respectively, with an overall accuracy of 33.33% for the probe. Finally, the Theory of

Mind levels (III-V) assessed following mastery of Double Reversed framing were 100%, 100% and 100% respectively, with an overall accuracy of 100% for the probe. When interpreted visually, overall accuracy on Theory of Mind measures improved in a linear fashion over time following the introduction of the relational frame training protocol.

Brian

Brian's baseline, intervention and maintenance data for all levels of deictic framing were depicted in *Figure 17*. Two points of baseline were collected for Simple frames, three points of data were collected for Reversed frames and four points of data were collected for Double Reversed frames. Average performances in baseline for Simple frames was 41.67% (range: 25% - 58.33%), 42.85% (range: 21.42 – 78.57%) for Reversed frames and 17.50% (range: 0% - 40%) for Double Reversed frames. Brian met criteria for mastery for Simple, Reversed and Double Reversed framing with 4, 3, and 6 sessions respectively. Brian maintained these gains in follow-up probes, with average accuracies in maintenance phases for Simple, Reversed and Double Reversed frames at 96.67% (range: 91.67% - 100%), 91.07% (range: 78.57% - 100%) and 80% (range: 80% - 80%) accuracies. In terms of visual analysis, the non-overlap between data in baseline and maintenance conditions indicates that the deictic training protocol produced improved rates of accuracy across all levels of framing difficulty. Brian demonstrated gains that persisted from training to maintenance conditions for all levels of relational complexity. Data indicating Brian's performance on Theory of Mind measures in baseline, following mastery of deictic framing with a single switch (Reversed frames) and following mastery of deictic framing with two switches (Double Reversed frames) are displayed in *Figure 17*. The three Theory of Mind levels (III-V) assessed in baseline were 33.33%, 66.67% and 16.67% respectively, with an

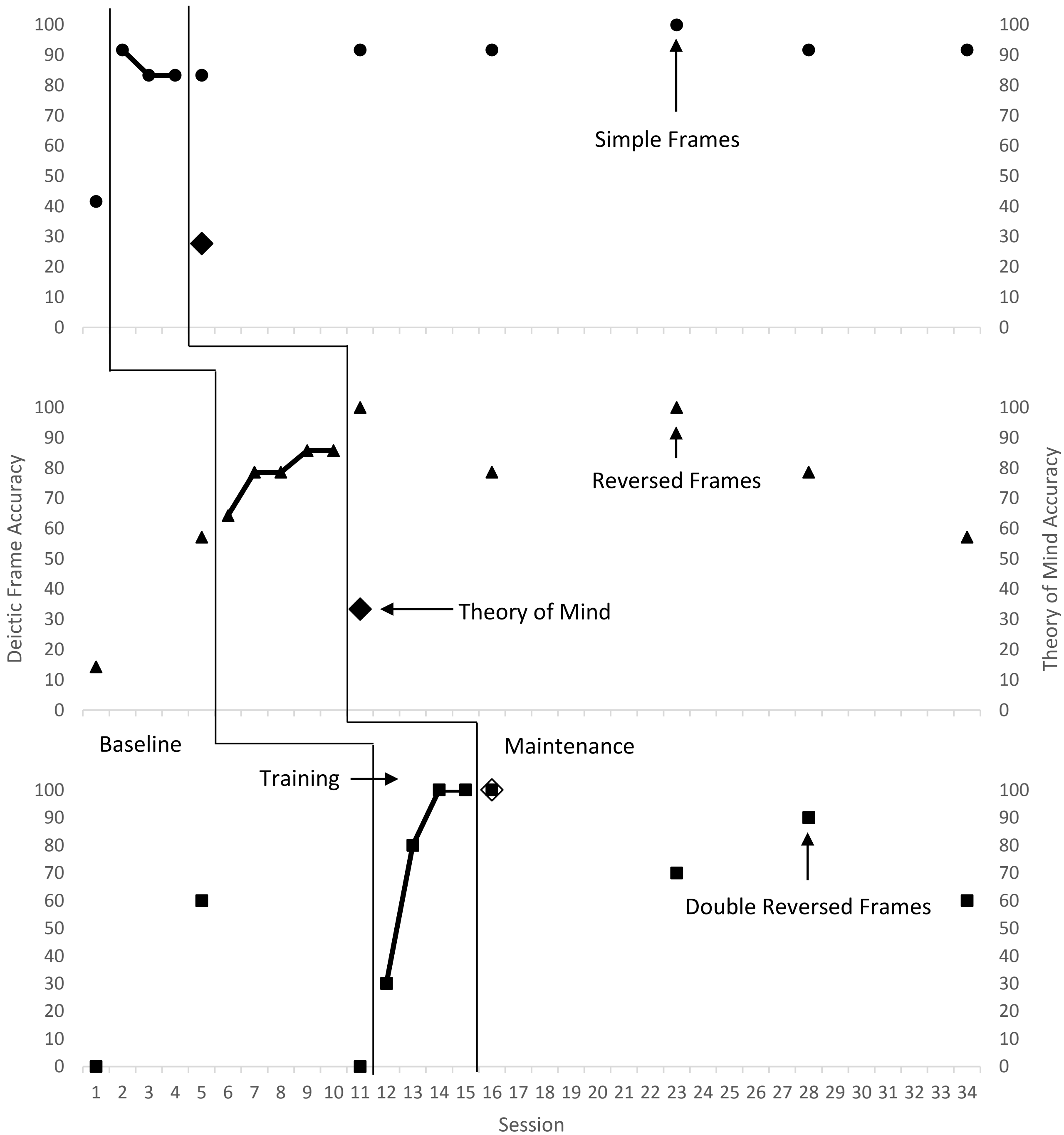


Figure 16. Deictic training and Theory of Mind data for Andrew

overall accuracy of 38.89% for the baseline probe. The Theory of Mind levels (III-V) assessed following mastery of Reversed framing were 50%, 33.33% and 66.67% respectively, with an overall accuracy of 50% for the probe. Finally, the Theory of Mind levels (III-V) assessed following mastery of Double Reversed framing were 83.33%, 33.33% and 100% respectively, with an overall accuracy of 72.22% for the probe. When interpreted visually, overall accuracy on Theory of Mind measures improved over time following improvements in deictic framing. These improved followed a linear trend of improvement throughout training on the relational frame training protocol.

Carl

Carl's baseline, intervention and maintenance data for all levels of deictic framing are depicted in *Figure 18*. Three points of baseline were collected for Simple frames, four points of data were collected for Reversed frames and five points of data were collected for Double Reversed frames. Average performances in baseline for Simple frames was 69.44% (range: 41.67% - 100%), 42.85% (range: 14.28 – 71.42%) for Reversed frames and 30% (range: 10% - 40%) for Double Reversed frames. Carl met criteria for mastery for Simple, Reversed and Double Reversed framing with 3, 6, and 4 sessions respectively. Carl maintained these gains in follow-up probes, with average accuracies in maintenance phases for Simple, Reversed and Double Reversed frames at 100%, 69.04% (range: 50% - 85.71%) and 75% (range: 70% - 80%) accuracies. In terms of visual analysis, the non-overlap between data in baseline and maintenance conditions indicates that the deictic training protocol produced improved rates of accuracy across all levels of framing difficulty. Carl maintained a high degree of accuracy from training to maintenance, though slight drops in accuracy were observed.

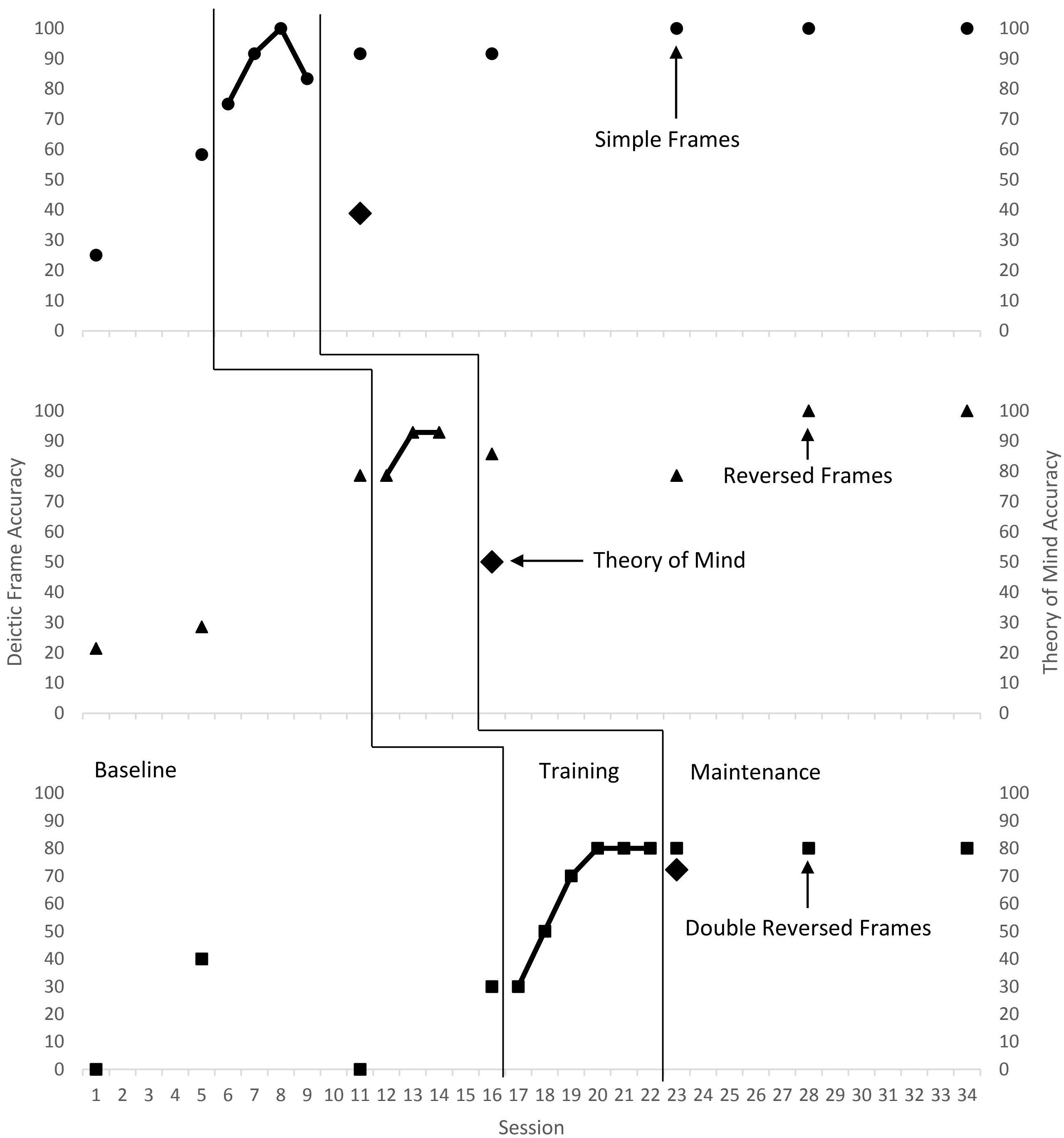


Figure 17. Deictic framing and Theory of Mind data for Brian

Data indicating Carl's performance on Theory of Mind measures in baseline, following mastery of deictic framing with a single switch (Reversed frames) and following mastery of deictic framing with two switches (Double Reversed frames) are displayed in *Figure 18*. The three Theory of Mind levels (III-V) assessed in baseline were 33.33%, 66.67% and 16.67% respectively, with an overall accuracy of 38.89% for the baseline probe. The Theory of Mind levels (III-V) assessed following mastery of Reversed framing were 66.67%, 0% and 0% respectively, with an overall accuracy of 22.22% for the probe. Finally, the Theory of Mind levels (III-V) assessed following mastery of Double Reversed framing were 83.33%, 100% and 100% respectively, with an overall accuracy of 94.44% for the probe. When interpreted visually, overall accuracy on Theory of Mind measures improved following successful completion of double reversed framing exercises improvements in deictic framing. While improvements were not linear in this case, near 100% accuracy was observed following the end of training.

David

David's baseline, intervention and maintenance data for all levels of deictic framing are depicted in *Figure 19*. Four points of baseline were collected for Simple frames, five points of data were collected for Reversed frames and six points of data were collected for Double Reversed frames. Average performances in baseline for Simple frames was 97.91% (range: 91.67% - 100%), 57.14% (range: 42.87% – 78.57%) for Reversed frames and 41.67% (range: 30% - 70%) for Double Reversed frames. David met criteria for mastery for Simple, Reversed and Double Reversed framing with 3, 4, and 4 sessions respectively. David maintained these gains in follow-up probes, with average accuracies in maintenance phases for Simple, Reversed and Double Reversed frames at 100%, 92.85% and 70% accuracies. In terms of visual analysis, the non-overlap between data in baseline and maintenance conditions indicates that the deictic

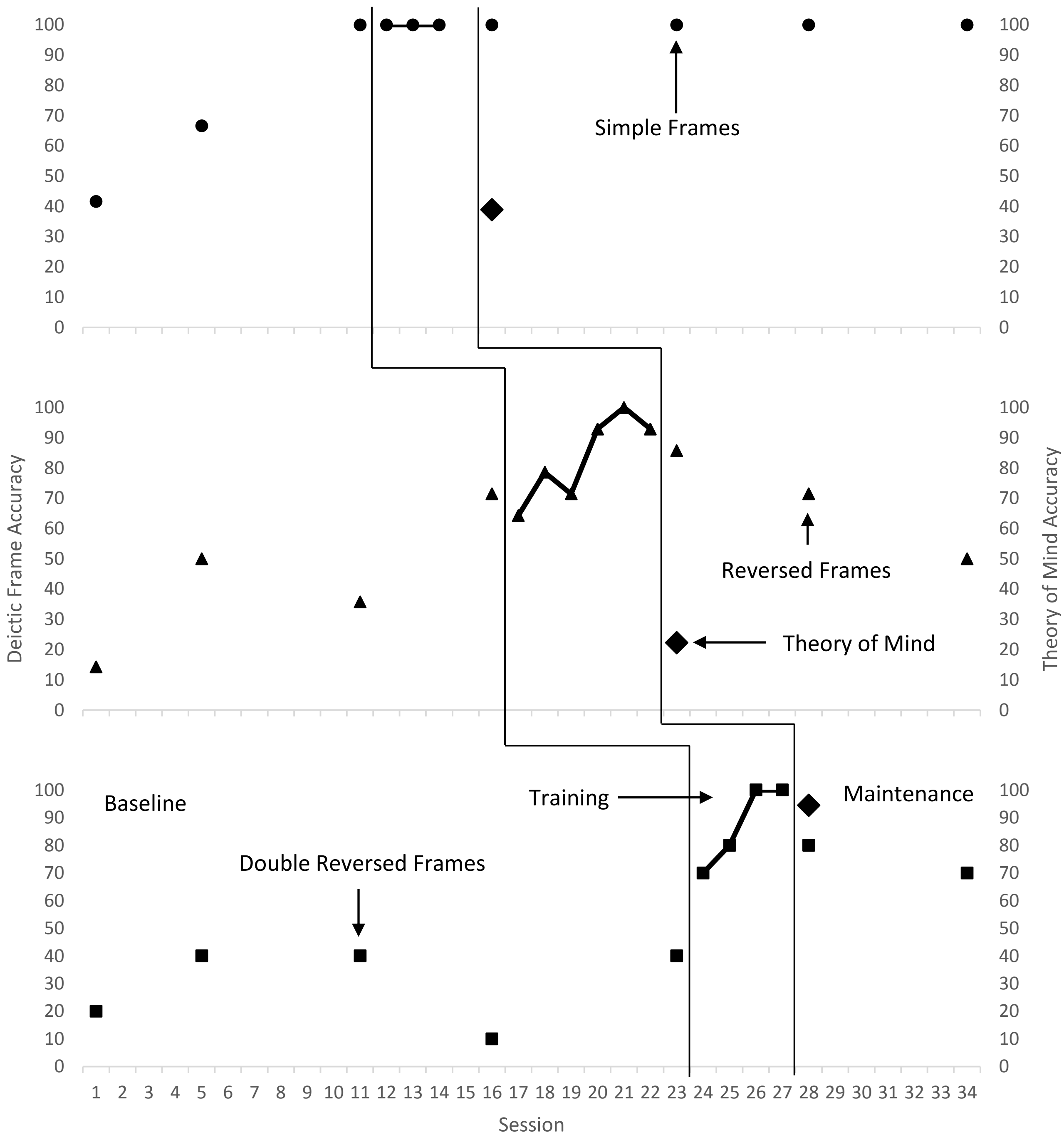


Figure 18. Deictic framing and Theory of Mind data for Carl

training protocol produced improved rates of accuracy across all levels of framing difficulty. Consistent with the expectations for an individual without an ASD, David acquired relational responding rapidly and often met high levels of accuracy (>80%) following only a single training session. Data indicating David's performance on Theory of Mind measures in baseline, following mastery of deictic framing with a single switch (Reversed frames) and following mastery of deictic framing with two switches (Double Reversed frames) are displayed in *Figure 19*. The three Theory of Mind levels (III-V) assessed in baseline were 50%, 66.67% and 33% respectively, with an overall accuracy of 50% for the baseline probe. The Theory of Mind levels (III-V) assessed following mastery of Reversed framing were 83.33%, 100% and 100% respectively, with an overall accuracy of 94.45% for the probe. Finally, the Theory of Mind levels (III-V) assessed following mastery of Double Reversed framing were 83.33%, 100% and 100% respectively, with an overall accuracy of 94.44% for the probe. When interpreted visually, overall accuracy on Theory of Mind measures improved following successful completion of double reversed framing exercises improvements in deictic framing.

Intervention Integrity

High levels of intervention integrity were observed throughout the intervention. Of all the trials implemented by the peer teacher, overall intervention integrity was calculated at 96.61%. Throughout the intervention there was 100% integrity for presenting all items, waiting for a peer to respond, providing breaks when requested, sharing views of the self-charting features and displaying of the latest leaderboard. Integrity of corrective feedback was 79.69%, which indicated 20% of the opportunities to deliver feedback did not occur (e.g., marked answer correct when incorrect). The results of the integrity checklist are displayed in Table 7.

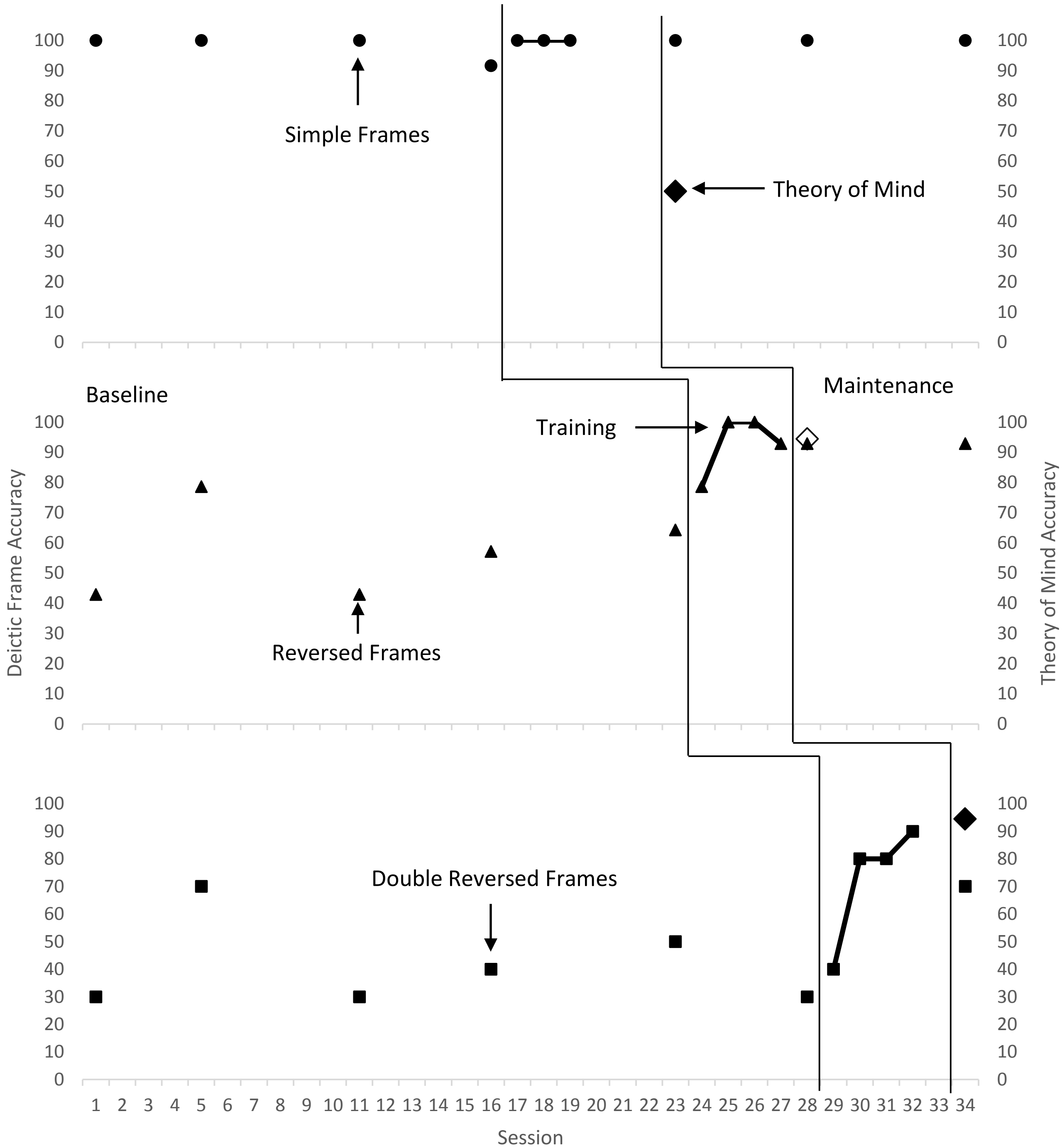


Figure 19. Deictic framing and Theory of Mind data for David

Table 7. Treatment Integrity Checklist for Student

Item	Average Score	Range of Scores (Session)
1. All trials were presented.	100%	-
2. All questions were attempted.	100%	-
3. Error corrections were provided when necessary.	79.69%	-
4. Short breaks were provided as necessary.	100%	-
5. The charting feature was presented.	100%	-
6. The leaderboard was presented.	100%	-
Overall Integrity	96.61%	83.33 – 100%

Peer Teacher Accuracy

Prior to, and throughout the study, the principal investigator conducted checks to confirm that the student running the lessons on the device indeed selected the correct option (e.g. recorded a correct or incorrect response). To minimize the likelihood of error, a teaching protocol was instituted prior to the running of any trials. The student was determined to be competent to run a trial with a peer following three instances of 100% accurate recording with the examiner. On-going checks continued throughout the study. Following training, the percentage of accuracy was estimated at 99.64% for all trials overall. The results of these checks are displayed in *Figure 20*. It is important to note, overall accuracy on sessions had to potential to be weighted differently given that individual sessions (e.g., one level) ranged from 10 to 14 opportunities and formal probes contained 36 opportunities (e.g., three levels).

Overall Outcomes of Deictic Framing Complexity

As shown in the above figures, the deictic framing protocol produced substantial improvement in both deictic framing accuracy and accuracy on traditional theory of mind measures. Overall improvements of deictic framing accuracy were visible through non-overlap of data and confirmed through high Percentages of Nonoverlapping Data (range: 81.81% to

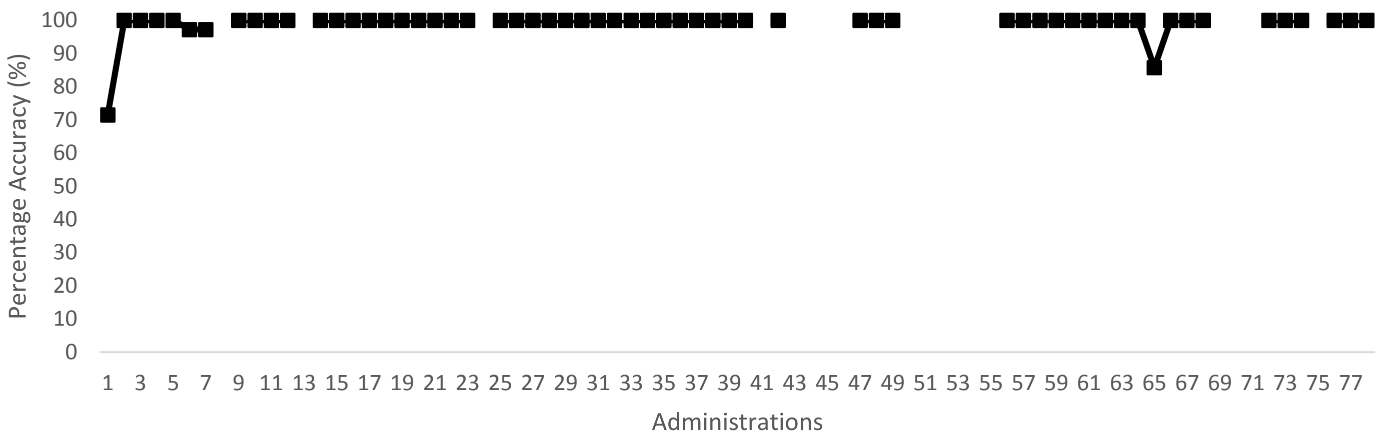


Figure 20. Accuracy of Peer Recording for Peer Teacher

100%) and Phi values (range: 0.633 to 1.0). A more robust display of values with confidence intervals is contained in *Figure 21*. As a supplement to visual analysis and measures of non-overlap data, a Welch Two Samples t-test was used to compare all pre-test to post-test performances. The results of the Welch's Two Samples T-test confirmed significant improvement between pre- and post-test for all participants (p = 0.000000000004988).

Pearson Phi and PAND for Deictic Training Across Baseline and Treatment/Maintenance

Frames	Lower Limit	Phi (95% CI)	Upper Limit	PAND
P1: Simple	0.0742	0.7	0.9277	91.66%
P1: Reversed	0.1468	0.7708	0.9300	90.90%
P1: D. Rev.	0.2775	1	1	100%
P2: Simple	0.1223	0.7619	0.9240	90%
P2: Reversed	0.2456	0.8194	0.9418	92.30%
P2: D. Rev.	0.1223	0.7619	0.9240	90%
P3: Simple	0.0849	0.6388	0.8627	84.61%
P3: Reversed	0.4159	1	1	100%
P3: D. Rev.	0.4111	1	1	100%
P4: Simple	0.2242	0.8166	0.9331	90.90%
P4: Reversed	0.0522	0.6333	0.8466	81.81%
P4: D. Rev.	0.0521	0.6333	0.847	81.81%
	0.7572	0.8924	0.9449	

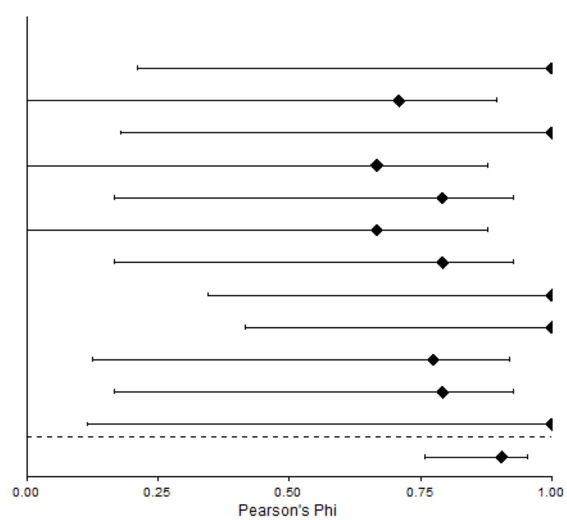


Figure 21. Pearson Phi and PAND across Baseline and Treatment/Maintenance Conditions

Overall Outcomes of Theory of Mind Performances

As shown in the figure below, training on the deictic framing protocol produced substantial improvements on traditional Theory of Mind measures when students met criteria for all levels of framing complexity (e.g., the final probe). Slight degrees of improvements were observed for all participants following mastery of the second level of framing complexity, but substantial improvements were apparent as participants mastered the higher level of framing complexity, as shown in *Figure 21*. As a supplement to visually interpreting these data, a paired samples t-test was used to compare Theory of Mind measures prior to (Probe 1) and following (Probe 3) deictic training. The results of the paired samples t-test converged with that of the visual interpretation, suggesting a significant difference ($p = 0.004236$).

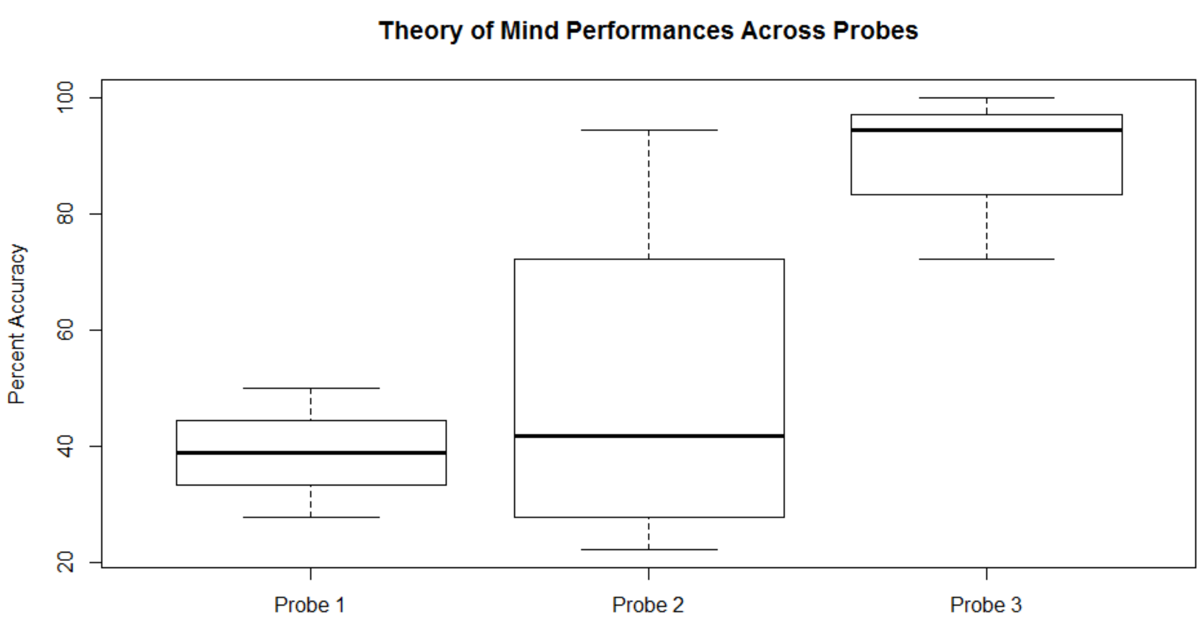


Figure 22. Theory of Mind Performances across Probes

Relationship between Deictic Framing Accuracy and Theory of Mind

As apparent in Figures 13-22, the degrees to which participants improved their accuracy on theory of mind probes rose alongside measures of relational complexity (e.g., Deictic Framing). Interestingly, improvements on Theory of Mind probes were marginal until participants mastered the highest level of relational complexity on the protocol (e.g., two transformations of stimulus function). To better understand the relationship between these variables, correlations were computed between ToM probes averages and deictic framing averages (e.g., at beginning, middle and final probe). For each participant, the first ToM probe was paired with the baseline deictic framing probe, the second theory of mind probe was paired with the deictic framing probe following mastery of reversed framing and the third theory of mind probe was paired with the deictic framing probe following mastery of double reversed framing. The results of individual correlation analyses for Andrew, Brian, Carl and David were 0.821, 0.886, 0.423 and 0.896 respectively, as shown in *Figure 16*. The results for Carl should be interpreted with caution, as his performances on the second Theory of Mind probe may have been negatively influenced by classroom-level factors at the time of measurement (e.g. sanctions for behavior earlier the day, etc.). Students having an autism spectrum diagnosis demonstrated gradual improvements in overall theory of mind and deictic framing accuracy only following training- David's performances should be interpreted with caution, as he had prior exposure to deictic content through teaching with the device. The overall correlation between overall accuracy on the deictic framing protocol and performances on traditional theory of mind measures yielded a correlation of 0.679, suggesting some degree of relationship between the two measures.

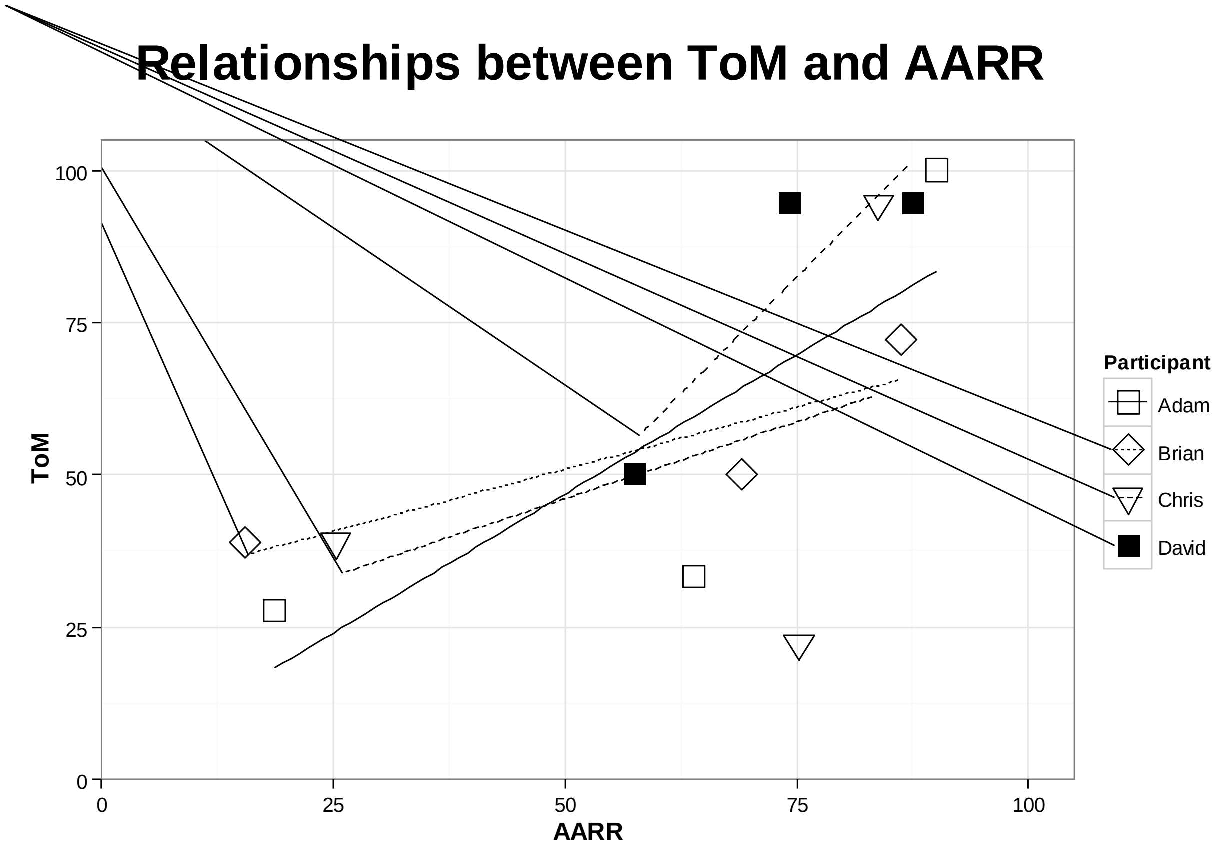


Figure 23. Relations between Theory of Mind and Deictic Framing

Adult Social Validity Survey

The results of acceptability measures with two special educators involved in the study indicated high levels of acceptability for both (1) an intervention to address the difficulties with perspective-taking present in a range of populations and (2) the use of technology as an avenue for delivering specialized intervention. The results of the acceptability survey with the classroom teacher and classroom paraprofessional indicated positive endorsements for teaching skills via mobile technology, for using games to deliver praise and feedback, for involving peers in others' learning and for having children deliver interventions to one another. Additionally, neither professional had concerns that game-based learning was disruptive and both approve of teaching using this type of intervention delivery. The results of the social acceptability survey are displayed in Table 8.

Table 8. Adult Social Validity Measures

Item	**Average Score**	**Range of Scores (1-6)**
1. The methods used to teach perspective-taking were appropriate.	6	6-6
2. A game-based approach delivered appropriate levels of feedback.	6	6-6
3. The perspective-taking protocol did not impact student relationships in a negative fashion.	5.5	5-6
4. A peer-mediated approach (with technology) was more feasible than a spoken (adult-led) version.	6	6-6
5. The methods used here would be good for use with other students as well.	6	6-6
6. The data collection and teaching trials did not disrupt my teaching.	6	6-6
7. I believe that teaching in this way is appropriate for my students.	6	6-6

Children's Social Validity Survey

The results of the social acceptability survey with the students involved in the study indicated high levels of acceptability for both (1) learning to take the perspective of another using deictic framing and (2) using technology as a tool for delivering material and feedback. Based on student report, students endorsed that the methods used to deliver instruction were fair, were not harsh or aversive and would be appropriate for others. Additionally, they did not report that competing with one another would cause problems with their friends and preferred using a tablet to acquire this type of repertoire. The results of the social acceptability survey for children are displayed in Table 9.

Table 9. Children Social Validity Measures

Item	**Average Score**	**Range of Scores (1-6)**
1. The methods used to teach perspective-taking were fair.	5.67	5-6
2. The teacher and computer game was too harsh on me.	2	1-3
3. The methods used to teach perspective-taking may cause problems with friends.	3	2-4
4. There are better ways to teach this type of behavior.	5	4-6
5. The methods used here would be good for use with other children as well.	6	6
6. I like the way I learned to take perspective using a tablet.	6	6
7. I think learning this way will help me in school	4.3	2-5

CHAPTER 5

DISCUSSION

Based on the results of this study, a range of likely conclusions have been drawn. With respect to the initial research questions, the results of this study suggest that a peer can be trained to implement an intervention using technology. More specifically, a specially-designed mobile device can successfully guide peer-mediated instruction while delivering reinforcement and error correction. This type of delivery produced improvements on measures of Theory of Mind following training to mastery on a modified Deictic Frame protocol (e.g., Barnes-Holmes protocol). With respect to implementation fidelity with children as the intervening agent, the data strongly support the notion that a child can be trained to implement a complex instructional intervention when technology is designed for their current skill-level. Careful design is necessary as the children “teaching” cannot be assumed to have all of the repertoires that are being taught and thus, should not deviate from the established protocol and error correction. The data also indicate that an instructional package can be successfully delivered through differential reinforcement and error correction when delivered by a mobile device. The accumulation of points, visual and auditory feedback and competitive leaderboards were an effective component of instruction. Lastly, the nature of the relationship between relational responding and measures of Theory of Mind provided additional evidence that suggested that the ToM framework may not adequately account for how perspective-taking emerges. Per the ToM framework, perspective-taking repertoires had been assumed to be the product of biological maturation, free of language ability or specific environmental training. Data from this study indicated that improved accuracy of language-based relational training (e.g., Deictic Training) produced relatively rapid improvements on the traditional measures of ToM. These findings highlight the role of the teaching and environment in the development of social behavior, which runs contrary to assumption of biological maturation as the primary factor in the development of these abilities.

A Technology for Intervention

Among the conclusions drawn, the notion that young children could be trained to implement a complex instructional intervention for another student, with a high degree of fidelity, is very telling. Historically, the demands of planning an activity, providing corrective or supportive feedback and recording student progress have been challenging for even the most seasoned and well-trained educators. A young child wouldn't be expected to have all of the prerequisite skills that seasoned educators have. However, the ever-expanding capabilities of technology has permitted a re-evaluation of the necessary skills to run an instructional session. With the advent of touchscreen technology, voice output, internet accessible and open-source software a range of possibilities are now within reach. These changes offer new avenues of research in education, psychology and behavior analysis. Given the high degrees of intervention fidelity throughout this study, it is entirely possible that children can be trained to teach one another children using such a technology for a range of applications. Much in the way assembly line workers may be trained to assemble an engine or electrical components without necessary understand the chemistry and mechanics of how they work, peer-mediated instructional approaches may be entirely possible for even very complex instructional material.

The promise of a new technology for teaching, for children, offers a significant range of possibilities and advantages. Speaking to this intervention alone, it is extremely unlikely that a 10- or 11-year old student could generate, articulate and provide feedback on complex and dynamic instructional content without substantial training. The results from McHugh et al., (2004) support this assumption, as these repertoires are thought to be improving throughout the lifespan. Technology with a carefully designed interface may circumvent the need for lengthy consultation and training related to intervention design, delivery, fidelity and even consistent data collection, as evident in Table 6. Beyond the instructional presentation of academic content, the automaticity of on-going data collection, visual analysis and immediate feedback reduced the overall time necessary to run such a session. The reduction in the overall time necessary to provide instruction is a benefit to any educator, regardless if they're a child or a teacher. In the context this study and the pilot study, a session using technology took between 5-10 minutes and a session using pencil-and-paper presentation and data collection (via the examiner) took 25-35 minutes. Beyond feasibility, overall integrity to instruction procedure was very high (overall integrity: 96.67%). Through carefully designed technology, the overall accuracy with respect to peers coding the correct student response (e.g., having a child identify the correct or incorrect response) was nearly perfect, as shown in *Figure 20*.

Aside from instructional and academic content altogether, technology itself permits access to a type of conditioned reinforcement that was previously inaccessible. Historically, many of the approaches necessary to enlist student participation have include edibles, access to non-academic materials (e.g., toys, computers, etc.) or the like. Through the inclusion of accumulated points, competitive leaderboards, dynamic feedback for correct and incorrect responding and immediate visual feedback, 100% of all reinforcement was mediated by the electronic device (e.g., no adult or external contingencies). The advantages to such an approach were very low rates of satiation, high degrees of motivation (e.g., to be at the top of a leaderboard) and very little time necessary to contact reinforcement (e.g., immediate access to a 5 second flash of the latest leaderboard with animated movement). Throughout the intervention protocol, no other reinforcement contingences were necessary to enlist student involvement beyond the feedback mediated by the device.

An instructional model for delivering content via peers could offer widespread benefit to a range of academic and teaching applications. In many cases, such an approach could even limit the reliance on adults to organize, deliver and monitor complex types of instruction. Instead, it may be entirely possible that a parent, paraprofessional or some other trained but non-educational staff could deliver and monitor skill acquisition. With respect to social skills and generalization, the inclusion of a peer as a teacher (e.g., not just an exemplar for training) may be more effective than traditional approaches altogether. Given the high degrees of acceptability by both adults and children, such an instructional model may be both effective and well-received.

Relational Frame Theory vs. a Developmental Theory of Mind

Beyond the contribution of technology itself, this study extended the current literature related to the development of perspective-taking in the ASD population. Historically the mainstream interpretations regarding the social and behavioral deficits of ASD (e.g., Theory of Mind) have emphasized the failure of biological maturation to occur. In such an account, the environment was considered to be less relevant to the development of these abilities (e.g., language and specific contingencies are unnecessary). In contrast to a developmental approach, Relational Frame Theory emerged as an alternative account to how individuals come to respond to relationally complex situations (e.g., deriving complex social relations) through the environment. Whereas ToM highlighted progression through a neurodevelopmental sequence, RFT highlighted how individuals come to respond to how items and events in the environment (including themselves) relate to one another through a process of differential reinforcement. Through an analysis of these types of social behavior in terms of relational frames (e.g., the arrangement of items and events), an environmental account of complex human behavior became readily available and applicable to these repertoires.

The results of this study indicated individuals with ASD demonstrated improvements in their accuracy of relational responding. Following this training, improvements on traditional measures of ToM (e.g., false belief tasks) were observed as reinforcement was delivered by a peer by way of mobile device. With respect to the accuracy of relational responding, all students demonstrated substantial improvements from baseline to training and follow-up, with varying degrees in their rates of acquisition. Overall, all students demonstrated substantial improvement on traditional measures of ToM as relational responding improved. When interpreted as an overall aggregate, overall improvements in the ability to answer relationally complex material (e.g., more complicated deictic frames) were strongly related to overall improvements on traditional measures of ToM.

The increasing utilization of RFT as a framework for teaching perspective-taking repertoires runs contrary to traditional assumptions regarding social behavior (e.g., ToM). For instance, the assumption that complex repertoires are primarily driven by biological maturation does not seem to hold true in this case. If ToM and biological maturation accounted for the improvements in relational accuracy, we would have expected to improvements in both baseline and training phases regardless of treatment or not. The fact that improvements were only observed in response to training and feedback suggests that a specific history of training (e.g., RFT and relational responding) more likely accounted for the improvements in these abilities. It is far less likely that biological maturation accounted for the acquisition of these repertoires or all participants, in such a short span of time (e.g., 4 weeks of intervention) and only following training.

Critiques of a Theory of Mind framework are not new. Beyond concerns that the developmental assumptions underpinning ToM and perspective-taking may be incomplete or insufficient, such an approach does not readily identify a training sequence or map of prerequisite skills that lead towards perspective-taking and social behavior. Rather, a developmental approach is largely premised on the assumption that if an individual can identify the "metarepresentational" informational states of another person (e.g., emotion, thoughts, etc.) then perspective-taking and a range of complex social behavior should come to follow eventually. Given a lack of direction, it is not surprising that randomly controlled trials of ToM teaching approaches have not been successful for socially significant behavior change (Steerneman, Jackson, Pelzer & Muris, 1996; Silver & Oakes, 2001; Fisher & Happe, 2005; Golan & Baron-Cohen, 2006; Gevers, Clifford, Mager & Boer, 2006; Beeger, Gevers, Clifford, Verhoeve, Kat, Hoddenbach & Boer, 2011; Gould, Tarbox, O'Hora, Noone & Bergstrom, 2011) and have not produced generalization beyond the teaching examples (Knoll & Charman, 2000; Golan & Baron-Cohen, 2006). Substantial concerns regarding the design and measurement inherent in a ToM framework have been raised as well. van Bujisen et al., (2011) found that simply presenting ToM tasks differently could account for improvements observed on tests of theory of mind. In contrast to ToM, a RFT account to understanding and teaching has demonstrated generalization across adults in a pilot study. This is likely due to the fact that relational responding draws more heavily from the environment and the context as the driving force for social behavior (Klin, 2000), rather than the guessing of informational states when planning how to react.

Relational Frame Theory as a Superior Framework for Teaching Complex Behavior

Among the many advantages of an ecological approach to a developmental approach, an environmental account of how complex repertoires develop could offer a more robust framework for designing intervention. Beyond increasing concerns that ToM is increasingly less-supported, a RFT approach offers a unified framework that extending from basic and well-established stimulus relations that scales up to complex human behavior. Per a RFT framework, complex human repertoires can be analyzed and taught through identifying and assessing relational repertoires. Given that deictic frames, a form of relational responding, are thought to be a prerequisite to perspective-taking, teaching such a repertoire may be a more data-based method to assess and remediate perspective-taking skills. When used in this way, relational training can guide the teaching of complex human behavior by targeting relational responding that may be deficient in a stepwise and predictable sequence. Such direction, scalability and consistency interpretation has not afforded in a ToM approach.

Limitations

Despite promising results that converged with earlier findings, several features of the study limit the conclusions that can be drawn. Among these factors, the participants sampled, the peers running the device, the specific devices used and methods for enlisting motivation and preference may not necessarily exert the same effects for all types of learners. Additionally, the lack of formal generalization probes and measures of actual social functioning limit the social validity of this type of intervention.

Derived Relational Responding and Single Case Design

The nature of derived stimulus relations offers additional levels of complexity to single cases research. In the analysis of deictic framing at multiple levels of complexity (e.g., simple, reversed and double reversed), these repertoires are inherently distinct. For example, the ability to derive relations following a single switch (e.g., reversed) requires that the individual can derive simple relations and the ability of derive relations following a double switch (e.g., double reversed) requires that the individual derive reversed relations. In this way, it is unlikely that specific levels of complexity can be trained without influencing other, more advanced levels (e.g., establishing simple relations likely influences reversed relations). As such, issues such as extended baselines or training phases have the potential to influence increasingly complex repertoires beyond those being trained at the time.

Participants

While most students in the study (three) had a diagnosis of an autism spectrum disorder, all students demonstrated a level of language, social and cognitive development that is not representative of the full range of autism spectrum disorders. More specifically, the rate of acquisition for deictic framing observed in these cases should not be considered characteristic of learners with autism who do not have commensurate social or language repertoires. In addition to the prerequisite skills, the age of the participants in the study is a substantial limitation to any definitive conclusion. Given that most typical children are expected to pass traditional false-belief tasks at an early age, meeting criteria in these measures when a child is in secondary school should not be granted the same weight as the former. Future revisions should explore intervention with younger participants, as done in Weil et al., 2011.

Peer Instructors

Throughout the study, high levels of treatment fidelity and accuracy were observed for the peer (the final participant) running the perspective-taking intervention. These levels were likely influenced by the high levels of supervision afforded from frequent fidelity checks. Frequent observations and measurement by the primary investigator likely produced an elevated level of adherence that may not have occurred at such levels if an adult had not been present for every session. The lack of a titration or thinning schedule of measurement (e.g., reduction of sessions without the investigator) limits the degree to which this study can ensure correct and adequate integrity beyond 100% adult supervision.

Devices

A potential limitation of the current study is the use of an Android device, a 7” tablet model specifically. The device used in the current study was a Google Nexus 7, commercially available for $99 at the current time. Given this cost, and the need for highly specialized and not yet available software, traditional and less technologically demanding measures may be more feasible and replicable (e.g. not limited to specific devices) in other instances. Additionally, more research should be pursued to determine if the specific sizes, makes and interfaces of specific mobile device platforms exerts influence on student behavior.

Preference Assessment

The use of an in-vivo preference assessment for conditioned reinforcement was another potential limitation to drawing definitive conclusions regarding a technologically-based peer-mediated intervention. Throughout these informal assessments, all participants demonstrated high levels of enthusiasm towards the accrual of computer points, high rankings on the leaderboard and other social conditioned reinforcers (e.g. successful notifications, self-charting, etc.). Such preferences may be a large component of this type of intervention if adults were to be increasingly removed, as the reliance on such a device to mediate specific reinforcement greatly limits the range of reinforcement on the basis of its original design and construction. It is entirely possible that some students may not demonstrate commensurate levels of enthusiasm for pre-programmed types of reinforcement or that interest in such events may diminish throughout training. In addition to these, it is also possible that age, gender and general interest in technology may influence efficacy of such an approach.

Generalization

Though measures of generalization have been included in previous iterations of this work, no assessments of generalization were included in this study due to time constraints (e.g., school scheduling). Given improvements on the deictic training protocol and ToM, without formal generalization measures, it is unclear to what degree perspective-taking abilities improved (if at all) in novel situations. The external validity of this type of approach, as improvements in other settings and contexts should be assessed thoroughly.

Future Research

Given the results of this study, peers and technology may be an avenue for expanding certain types of skill repertoires. However, future research should continue along several lines. Among these lines, researchers should further explore the effectiveness of such an approach (e.g., peer-mediated technology), the external validity of these approaches (e.g. in novel social or academic contexts) and the degree to which children can maintain procedural fidelity in such an approach.

In order to evaluate the effects of relational training, future research should expand beyond the scope of relational responding in this study. Given that specific types of relational framing are operants themselves, additional attention is warranted to the benefits of accuracy with increasing complex types of relational responding. In this study, substantial improvements were only seen following the most complex relational content (e.g., two frame switches). Additional research should be conducted in order to better understand how relational responding, and its level of complexity, relate to complex social behavior.

In addition to research on deictic framing specifically, the external validity of these gains must be further explored. Given that research in this area has focused on the development of social behavior in older populations, improvements in younger or exceptional groups may not be commensurate. As such, additional research in both the training of young and school-age children must be conducted with attention specific to the corresponding social and language gains for these populations. Future research with younger populations may take the form of less vocal, visually-based methods for younger populations who may have not yet developed vocal language repertories to such a degree.

Though research into the applications of technology continues to expand, research specific to the design of technology and use with children has yet to be explored from a behavior analytic viewpoint. The use of technology as a teaching tool has been explored, though the role of technology as a mediator of reinforcement (e.g. without an adult present) has not yet fully explored in the context of intervention. Given the capabilities of a mobile device to mediate reinforcement in and of itself (e.g. the allocation of points, improvement of rankings, etc.), research into the use of a device as a member of the verbal community should be explored.

Lastly, and perhaps with the greatest novelty, the integrity of such a training protocol must be researched thoroughly. In recent years, intervention integrity (with adults) has been an area of great interest in education and behavior analysis. However, the fidelity of intervention when delivered by a child is likely to produce novel barriers to intervention. Though the breadth of possibilities for human error were minimized through the development of technology specific to children, the age and skill-levels of peer teachers is likely to be a factor in their ability to implement such an intervention with integrity.

Summary

Despite the limitations presented, all participants in the study acquired a relational responding repertoire. All three students with an autism spectrum disorder met criteria for mastery, as did the final peer that implemented the teaching trials. Additionally, all students demonstrated improvements on traditional theory of mind tasks, consistent with earlier research findings. Similarly, relational responding accuracy was correlated with accuracy on traditional measures of theory of mind, suggesting that relational responding likely underpins certain types of complex social behavior (e.g. perspective-taking).

Beyond the improvements in relational responding, this study also illustrated the capabilities of a student when technology was designed and utilized from a clinical perspective. Through an interface designed for a child, using visually-mediated strategies and immediate feedback a complete intervention package was delivered with no direct influence by an adult. Even beyond integrity, the use of a leaderboard and a point system removed the need for an adult to mediate any reinforcement at all throughout the intervention. Lastly, all parties involved in the study reported high levels of acceptability with both the deictic training protocol as well as the method of delivery. Classroom teachers highlighted that such an approach was feasible, inexpensive, free of time-consuming data collection and was not disruptive to other students in the class. Students participating in the study highlighted their preference for a mix of visual and vocal material, the frequent accumulation of points, the pleasing sound effects, the visual transitions and the use of a leaderboard for motivation.

REFERENCES CITED

Barnes, D. (1994) Stimulus equivalence and relational frame theory. *The Psychological Record, 44,* 91-135.

Barnes, D. & Roches, B. (1997). A behavior-analytic approach to behavioral reflexivity. *The Psychological Record, 47,* 543-572.

Barnes-Holmes, D., Barnes-Holmes, Y., Smeets, P. M., Cullinan, V. Leader, G. (2004). Relational Frame Theory and Stimulus Equivalence: Conceptual and Procedural Issues. *International Journal of Psychology & Psychological Therapy, 4(2),* 181-214.

Barnes-Holmes, Y., McHugh, L., & Barnes-Holmes, D. (2004). Perspective-taking and theory of mind: A relational frame account. *The Behavior Analyst Today, 5,* 15-25.

Baron-Cohen, S. (1993). From attention-goal psychology to belief-desire psychology: the development of a theory of mind, and its dysfunction. In S. Baron-Cohen, H. Tager-Flusberg, and D.J.Cohen (Eds.), *Understanding Other Minds: Perspectives from Autism*. New York: Oxford University Press.

Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind*. Cambridge, M.A.: Bradford Books, MIT Press.

Baron-Cohen, S. (1997). Hey! It was just a joke! Understanding prepositions and propositional attitudes by normally developing children and children with autism. *Israel Journal of Psychiatry & Related Sciences, 34,* 174-178.

Baron-Cohen, S., Leslie, A., & Frith, L. (1985). Does the autistic child have a theory of mind? *Cognition, 21,* 37-46.

Baron-Cohen, S., Tager-Flusberg, H., & Cohen, D. (2000). *Understanding other minds: Perspectives from developmental cognitive neuroscience. 2nd ed.* Oxford: Oxford University Press.

Beeger, S., Gevers, C., Clifford, P., Verhoeve, M., Kat, K., Hoddenbach, E. & Boer, F. (2011). Theory of Mind Training in Children with Autism: A Randomized Controlled Trial. *Journal of Autism and Developmental Disorders, 41,* 997-1006.

Bloom, P. & German, T. P. (2000). Two reasons to abandon the false belief task as a test of theory of mind. *Cognition, 77,* 25-31.

Carlson, S. M., Moses, L. J., & Hix, H. R. (1998). The role of inhibitory processes in young children's difficulties with deception and false belief. *Child Development, 69,* 672-691.

Chung, K. M., Reavis, S., Mosconi, M., Drewry, J. Matthews, T. & Tasse. (2007). Peer-mediated social skills training program for young children with high-functioning autism. *Research in Developmental Disabilities, 28,* 423-436.

Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). *Applied behavior analysis (2nd ed.)*. Upper Saddle River, NJ: Pearson.

Davlin, N. L., Rehfeldt, R. A., & Lovett, S. (2011). A relational frame theory approach to understanding perspective-taking using children's stories in typically developing children. *European Journal of Applied Behavior Analysis*, *12*, 403-430.

De Los Reyes, A., & Kazdin, A. (2006). Conceptualizing changes in behavior in intervention research: The range of possible changes model. *Psychological Review, 113,* 554–583.

Diehl, J. J., Schmitt, L. M., Villano, M. & Crowell., C. R. (2012). The clinical use of robots for individuals with Autism Spectrum Disorders: A critical review. *Research in Autism Spectrum Disorders, 6,* 249-262.

DiGennaro-Reed, R. D., Hyman, S. R., & Hirst, J. M. (2011). Applications of technology to teach social skills to children with autism. *Research in Autism Spectrum Disorders, 5,* 1003-1010.

Dougher, M. J., Auguston, E. M., 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*, 331-352.

Dymond, S., & Barnes, D., 1994, A transfer of self-discrimination response functions through equivalence relations. *Journal of the Experimental Analysis of Behavior*, *642*, 251-267.

Dymond, S. & Barnes, D. (1995). A transformation of self-discrimination response functions through the arbitrarily applicable relations of sameness, more-than, and less-than. *Journal of the Experimental Analysis of Behavior, 64*, 163-184.

Dymond, S., Roche, B., Forsyth, J. P., Whelan, R., & Rhoden, J. (2007). Transformation of avoidance response functions in accordance with same and opposite relational frames. *Journal of the Experimental Analysis of Behavior, 88,* 249-262.

Fay, W. H. (1979). Personal pronouns and the autistic child. *Journal of Autism and Developmental Disorders, 9*, 247–260.

Fisher, N. & Happe, F. (2005). A training study of Theory of Mind and executive function in children with autistic spectrum disorders. *Journal of Autism and Developmental Disorders, 35,* 757-771.

Flavell, J. H., & Miller, P. H. (1998). Social cognition. In D. Kuhn & R. Siegler (Vol. Eds.), W. Damon (Series Ed.) Handbook of child psychology: Vol. 2. Cognition, perception, and language (pp. 851–898). New York: Wiley.Foxx, R. M. (2008). Applied Behavior Analysis Treatment of Autism: The State of the Art. *Journal of Child and Adolescent Psychiatric Clinics of North America, 17(4),* 821-834.

Freeman, N., Lewis, C., & Doherty, M. J. (1991). Making explicit the 3-year-old's implicit competence with their own false beliefs. *Cognition, 56,* 31-60.

Frith, U. & Happe, F. (1994). Autism: beyond "theory of mind". *Cognition, 50,* 115-132.

Gevers, C., Clifford, P., Mager, M., & Boer, F. (2006). Brief report: A ToM-based social cognition training program for school-aged children with PDD: an open study of its effectiveness. *Journal of Autism and Developmental Disorders, 36,* 567-571.

Golan, O. & Baron-Cohen, S. (2006). Systemizing empathy: Teaching adults with Asperger syndrome or high-functioning autism to recognize complex emotions using interactive multimedia. *Developmental and Psychopathology, 18,* 591–617.

Gould, E., Tarbox, J., O'Hora, D., Noone, S. & Bergstrom, R. (2011). Teaching children with autism a basic component skill of perspective-taking. *Behavioral Interventions, 26,* 50-66.

Grynszpan, O., Martin, J. C. & Nadel, J. (2008). Multimedia interfaces for users with high functioning autism: An empirical investigation. *International Journal of Human-Computer Studies, 66,* 628-639.

Halford, G. S., Wilson, W. H., & Phillips, S. (1998). Processing capacity defined by relational complexity: Implications for comparative, developmental, and cognitive psychology. *Behavioural & Brain Sciences, 21*, 803-864.

Happe, F. (1993). Communicative competence and Theory of Mind in autism: A test of relevance theory. *Cognition, 48,* 101-119.

Hayes, S. C. (1984). Making sense of spirituality. *Behaviorism, 12*, 99-110.

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

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

Hayes, S. C., Barnes-Holmes, D., & Roche, B. (2001). (Ed's.), *Relational frame theory: A post-Skinnerian account of language and cognition*. New York: Plenum Press.

Hayes, S. C., Brownstein, A. J., Devany, J. M., Kohlenberg, B. S., & Shelby, J., 1987, Stimulus Equivalence and the symbolic control of behavior, *Mexican Journal of Behavior Analysis*, *13*, 361-374.

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, (Ed's.), *Relational frame theory: A post-Skinnerian account of language and cognition.* New York: Plenum Press.

Hayes, S. C., Kohlenberg, B. K., & Hayes, L. J, 1991, The transfer of specific and general consequential functions through simple and conditional equivalence classes, *Journal of the Experimental Analysis of Behavior, 56,* 119-137.

Heagle, A. & Rehfeldt, R. A. (2006). Teaching perspective-taking skills to typically developing children through derived relational responding. *Journal of Early and Intensive Behavior Intervention, 3,* 1-34.

Hobson, P. R., Garcia-Perez, R. M., Lee, A. (2010). Person-centered (Deictic) Expressions and Autism. *Journal of Autism and Developmental Disorders, 40,* 403-415.

Hobson, R. P., & Meyer, J. A. (2005). Foundations for self and other: A study in autism. *Developmental Science, 8,* 481–491.

Holth, P. (2005). An operant analysis of joint attention skills. *Journal of Early and Intensive Behavior Interventions, 2,* 160-175.

Horner, R. D. & Baer, D. M. (1978). Multiple-probe technique: A variation of the multiple baseline design. *Journal of Applied Behavior Analysis, 11, 189-196.*

Howlin, P., Baron-Cohen, S., & Hadwin, J. (1999). *Teaching children with autism to mind-read: A practical guide*. Chichester, England: Wiley.

Howlin, P. (2008). Can children with autism spectrum disorders be helped to acquire a "theory of mind"? *Revisita de Logopedia, Foniatría y Audiología, 28,* 74-89.

Hyman, S. L. & Towbin, K. E. (2009). Autism Spectrum Behavior. In M. L. Batshaw, L. Pellegrino & N. J. Roizen, *Children with Disabilities. 6th ed.* Maryland: Brooks Publishing.

Klin, A. (2000). Attributing social meaning to ambiguous visual stimuli in higher-functioning autism and Asperger syndrome: The social attribution task. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 41*, 831–846.

Knoll, M. & Charman, T. (2000). Teaching false belief and visual perspective-taking skills in young children: Can a theory of mind be trained? *Child Study Journal, 30,* 273 – 304.

Koegel, L. K., Koegel, R. L., Harrower, J. K. (1999). Pivotal Response Training I: Overview of approach, *Journal of the Association for Persons with Severe Handicaps, 24(3)*, 174-186.

Koenig, K., De Los Reyes, A., Cichetti, D., Scahill, L. & Klin, A. (2009). Group Intervention to Promote Social Skills in School-age Children with Pervasive Developmental Disorders: Reconsidering Efficacy, *Journal of Autism and Developmental Disorders, 39,* 1163-1172.

LeBlanc, L., Coates, A., Daneshvar, S., Charlop-Christy, M., Morris, C. & Lancaster, B. (2003). Using video modeling and reinforcement to teacher perspective-taking skills to children with autism. *Journal of Applied Behavior Analysis, 36,* 253-257.

Leekham, S., & Perner, J. (1991). Does the autistic child have a metarepresentational deficit? *Cognition, 40*, 203-218.

Leekam, S., Perner, J., Healey, L., & Sewell, C. (2008). False-signs and the non-specificity of theory of mind: Evidence that presechoolers have general difficulties in understanding representations. *British Journal of Developmental Psychology*, *26,* 485-497.

Leslie, A. M. (1984). Pretend play and representation in infancy: A cognitive approach. In A. R. A. P. I. (Eds.), *Contributions a la recherce scientifique sur I'autisme aspects cognitifs*. Pans Association pour la Recherche sur l'Autisme et les Psychoses Infantiles.

Lewis, C. & Osborne, A. (1990). Three-year-olds' problems with false belief: conceptual deficit or linguistic artifact? *Child Development, 61*, 1514-1519.

Lipkens, G., Hayes, S. C., & Hayes, L. J. (1993). Longitudinal study of derived stimulus relations in an infant. *Journal of Experimental Child Psychology, 56*, 201-239.

Lorah, E. R., Gilroy, S. P. & Hineline, P. N. (2014). Acquisition of peer manding and listener responding in young children with autism. *Research in Autism Spectrum Disorders, 8,* 61-67.

Martens B.K, Witt J.C, Elliott S.N, Darveaux D. Teacher judgments concerning the acceptability of school based interventions. *Professional Psychology: Research and Practice*, 16, 191–198.

Mason, R., Kamps, D., Turcotte, A., Cox, S., Feldmiller, S. & Miller, T. (2014). Peer mediation to increase communication and interaction at recess for students with autism spectrum disorders. *Research in Autism Spectrum Disorders, 8,* 334-344.

McHugh, L., Barnes-Holmes, Y., Barnes-Holmes, D. (2004). Perspective-taking as Relational Responding: A Developmental Profile. *The Psychological Record, 2004,* 115-144.

McHugh, L., Barnes-Holmes, Y., & Barnes-Holmes, D. (2009). *Understanding and training perspective taking as relational responding*. In Rehfeldt, R. A. & Barnes-Holmes, Y. (2009). Derived relational responding: Applications for learners with autism and other developmental disabilities: Context Press- New Harbinger Publications, Inc.

McHugh, L., Barnes-Holmes, Y., O'Hora, D. & Barnes-Holmes, D. (2004). Perspective-taking: A relational frame analysis. *Experimental Analysis of Human Behavior Bulletin*, *22*, 4-10.

McHugh, L., Barnes-Holmes, Y., Barnes-Holmes, D., Stewart, I., & Dymond, S. (2007). Deictic relational complexity and the developmental of deception. *The Psychological Record, 2007*, 517-531.

Miguel, C. F. & Petursdottir, A. I. (2009). *Naming and frames of coordination*. In Rehfeldt, R. A. & Barnes-Holmes, Y. (2009). Derived relational responding: Applications for learners with autism and other developmental disabilities: Context Press- New Harbinger Publications, Inc.

Mintz, J., Branch, C., March, C. & Lerman, S. (2012). Key factors mediating the use of a mobile technology tool designed to develop social and life skills in children with Autistic Spectrum Disorders. *Computers & Education, 58,* 53-62.

Moses, L. J. (1993). Young children's understanding of belief constraints on intention. *Cognitive Development, 8,* 1-25.

Mossler, D. (1976). Conceptual perspective-taking in 2- to 6-year old children. *Developmental Psychology*, 12, 85-86.

Ninness, C., Holland, J., McCuller, G., Rumph, R., Ninness, S., McGinty, J. (2009) *Mathematical reasoning.* In Rehfeldt, R. A. & Barnes-Holmes, Y. (2009). Derived relational responding: Applications for learners with autism and other developmental disabilities: Context Press- New Harbinger Publications, Inc.

Peláez, M. (2009). *Joint attention and social referencing in infancy as precursors of derived relational responding*. In Rehfeldt, R. A. & Barnes-Holmes, Y. (2009). Derived relational responding: Applications for learners with autism and other developmental disabilities: Context Press- New Harbinger Publications, Inc.

Pellecchia, M. & Hineline, P.N. (2007). Generalization of mands in children with autism from adults to peers. *The Behavior Analyst Today, 8,* 483- 491.

Perner, J., Frith, U., Leslie, A. M., & Leekam, S. R. (1989). Exploration of the autistic child's theory of mind: knowledge, belief, and communication. *Child Development, 60,* 689-700.

Perner, J., Leekam, S., & Wimmer. H, (1987). Three year olds' difficulty with false belief. The case for a conceptual deficit. *British Journal of Developmental Psychology, 5,* 125-137.

Plastow, M. (2012). 'Theory of Mind' I: a theory of knowledge? *Australasian Psychiatry, 20,* 199-202.

Rehfeldt, R. A., Dillen, J. E., Ziomek, M. M. & Kowalchuck, R. K. (2007). Assessing relational learning deficits in perspective-taking in children with high-functioning autism spectrum disorder. *The Psychological Record, 57,* 23-47.

Rehfeldt, R. A., & Barnes-Holmes, Y. (2009). *Derived relational responding: Applications for learners with autism and other developmental disabilities: a progressive guide to change*. Reno, NV: Context Press.

Roche, B., Barnes-Holmes, D., Smeets, P. M., Barnes-Holmes, Y., & McGeady, S. (2000). Contextual control over the derive transformation of discriminative and sexual arousal functions. *The Psychological Record, 50*, 267-291.

Rogers, S. & Vismara, L. (2008). Evidence-based comprehensive treatments for early autism. *Journal of Clinical & Adolescent Psychology, 37,* 8-38.

Rosales, R. & Rehfeldt, R. A. (2009). *Extending functional communication through relational framing.* In Rehfeldt, R. A. & Barnes-Holmes, Y. (2009). Derived relational responding: Applications for learners with autism and other developmental disabilities: Context Press-New Harbinger Publications, Inc.

Sabbagh, M., & Taylor, M. (2000). Neural correlates of theory-of-mind reasoning: An event related potential study. *Psychological Science, 11,* 46-50.

Scattone, S. (2007). Social skills interventions for children with autism. *Psychology in the Schools, 44(7)*, 717-726.

Sidman, M. (1971). Reading and auditory-visual equivalences. *Journal of Speech and Hearing Research, 14,* 5-13.

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

Siegal, M., & Beattie, K. (1991). Where to look first for children's knowledge of false beliefs. *Cognition, 38,* 1-12.

Silver, M., & Oakes, P. (2001). Evaluation of a new computer intervention to teach people with autism or Asperger syndrome to recognize and predict emotions in others. *Autism, 5,* 299-316.

Skinner, B. F. (1957). Verbal Behavior. New York: Appleton-Century-Crofts.

de Souza, D. G., de Rose, J. C., & Demeniconi, C. (2009). *Applying relational operants to* *reading and spelling*. In Rehfeldt, R. A. & Barnes-Holmes, Y. (2009). Derived relational responding: Applications for learners with autism and other developmental disabilities: Context Press- New Harbinger Publications, Inc.

Steele, D. L. & Hayes, S. C. (1991). Stimulus equivalence and arbitrarily applicable relational responding. *Journal of the Experimental Analysis of Behavior*, *56*, 519-555.

Steerneman, P., Jackson, S., Pelzer, H., & Muris, P. (1996). Children with social handicaps: An intervention program using a ToM approach. *Clinical Child Psychology & Psychiatry, 1*, 251-263.

Surian, L. & Leslie, A. M. (1999). Competence and performance in false belief understanding: a comparison of autistic and three-year-old children. *British Journal of Developmental Psychology*, *17,* 141-155.

Taylor, M, (1988), Conceptual perspective taking: Children's ability to distinguish what they know from what they see. *Child Development,* 59, 703-718.

Villatte, M., Monestès, J. L., McHugh, L., Freixa i Baqué, E., & Loas, G. (2010). Assessing perspective taking in schizophrenia using relational frame theory. *The Psychological Record, 60,* 413-436.

Wang, S. Y., Cui, Y. & Parrila, R. (2011). Examining the effectiveness of peer-mediated and video-modeling skills interventions for children with autism spectrum disorders: A meta-analysis in single-case research using HLM. *Research in Autism Spectrum Disorders, 5,* 562-569.

Weil, T. M., Hayes, S. C., & Capurro, P. (2011). Establishing a deictic repertoire in young children. *The Psychological Record, 61,* 371-390.

Wellman, H., & Bartsch, K. (1988). Young children's reasoning about beliefs. *Cognition, 30*, 239-277.

Witt, J. C. & Elliott, S. N. (1985). Acceptability in classroom intervention settings. In T. R. Kratochwill (Ed.), *Advances in school psychology* (4th ed.) (pp. 251-288). Mahway, NJ: Erlbaum.

Valdivia-Salas, S., Luciano, C., Gutierrerz-Martinez, O., & Visdomine, C. (2009) *Establishing empathy.* In Rehfeldt, R. A. & Barnes-Holmes, Y. (2009). Derived relational responding: Applications for learners with autism and other developmental disabilities: Context Press-New Harbinger Publications, Inc.

van Buijsen, M., Hendriks, A., Ketelaars, M., & Verhoeven, L. (2011). Assessment of Theory of Mind in children with communication disorders: Role of presentation mode. *Research in Developmental Disabilities, 32,* 1038-1045.

Vilardaga, R. (2009). A Relational Frame Theory Account of Empathy. *International Journal of Behavioral Consultation and Therapy, 5,* 178-184.

Wimmer, H., & Perner, J. (1983) Beliefs about beliefs representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition,* 13, 103-128.

Wellman, H. M. (1990). *The child's theory of mind*. Cambridge, M.A: MIT Press, A Bradford Book.

Wellman, H. M., Cross, D. & Watson, J. (2003). Meta-Analysis of Theory-of-Mind Development: The Truth about False Belief. *Child Development*, *72,* 655-684.

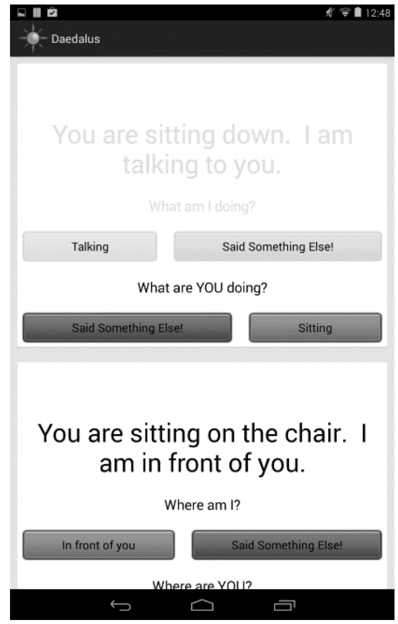
Zhang, J. & Wheeler, J. J. (2011). A meta-analysis of peer-mediated interventions for young children with autism spectrum disorders. *Education and Training in Autism and Developmental Disabilities, 46*, 62-77.

Zaitchik, D. (1991). Is only seeing really believing? Sources of true belief in the false belief task. *Cognitive Development*, *6*, 91-103.

APPENDIX

List of current students by "team" or username

User interface of peer teacher



Points and place in leaderboard

Error correction and self-charting interfaces