Intervention Programs for Individuals with Autism Spectrum Disorder: Development, Implementation, and Outcomes

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APPROVAL OF THE DISSERTATION

This dissertation, "Intervention Programs for Individuals with Autism Spectrum Disorder: Development, Implementation, and Outcomes" has been approved by the Graduate Faculty of the Curry School of Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Clinical Psychology.

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Dedication

This work is dedicated to my family, genetic and extended. To my parents, Jane and Marney Cox, I could not have come this far without your support and encouragement along my professional and academic journey. My sister Sarina Cox Lynn, I cannot imagine the past four years without you (and Jeff) on speed dial. Jessica Burnett Emsley and Erin MacNeil Ellison, who have kept me anchored in chaos, and are my constant cheerleaders.

I am fortunate to have so many wonderful role models of intelligence, achievement, and compassion in my life. I love you all.

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Three Manuscript Dissertation Overview

My research focuses on the development, implementation, and outcomes of intervention programs for individuals with Autism Spectrum Disorder (ASD). The variation of the clinical phenotype and uncertain developmental trajectory of this population make these efforts especially challenging. My dissertation is comprised of three manuscripts investigating interventions designed to target skill development at two distinct developmental stages: early childhood and late adolescence.

The Curry School Guidelines require the doctoral candidate to principal author all three manuscripts and submit a linking document that demonstrates the conceptual and theoretical linkages among the three manuscripts. I am the lead author on all three manuscripts.

The first manuscript, *Comparative Effectiveness of Behavioral and Developmental Approaches in Communication Intervention for Children with Autism Spectrum Disorder* was presented at the American Speech-Language-Hearing Association Convention in 2013. Preliminary results from the second study, *Driving Performance in Individuals with Autism Spectrum Disorders: A pilot study investigating the role of executive functioning,* were presented at the International Meeting for Autism Research and the American Psychological Association Convention in 2013. This manuscript has been revised and resubmitted to the Journal of Autism and Developmental Disabilities. The third study, *An Evaluation of Behavioral and Developmental Communication Interventions for Children with Autism Spectrum Disorder* was presented at the American Speech-Language-Hearing Association Convention in 2014 and will be submitted to the appropriate refereed journal upon completion.

The remainder of this document includes the rationale for the line of research (pp. 11-27), the complete manuscript for study 1 (pp. 28-52), the completed manuscript for study 2 (pp. 53-87), and the completed manuscript for study 3 (pp. 88-140).

Intervention Programs for Individuals with Autism Spectrum Disorder

Notable and substantial gains have been made by researchers and practitioners in research, diagnosis, and treatment of Autism Spectrum Disorder (ASD). Despite decades of investigations, earlier age of diagnosis, and refined treatment methods, numerous questions remain unanswered. These questions have become increasingly pressing with rising prevalence rates (most recently estimated at 1 in 68; Baio, 2014) and the recent changes to diagnostic criteria in the Diagnostic and Statistical Manual (DSM-5; American Psychiatric Association, 2013). Researchers and policy makers (Koegel, 2000; Goldstein, 2002; Lord et al., 2005; Rogers & Vismara, 2008; Smith et al., 2007) have called for empirical investigations of interventions that address methodological concerns and gaps in evidence present in the current literature.

Families and clinicians have an overwhelming number of intervention approaches to choose from, including, but not limited to, those designed to address the following concerns related to ASD: speech and language, maladaptive behavior, play skills, and sensory integration. Further complicating the selection and implementation of intervention, multiple treatment methods exist within each symptom cluster of focus, including: developmental, naturalistic, behavioral, alternative, and eclectic approaches.

No matter the targeted skill or selected method, a majority of intervention approaches are expensive and require hundreds to thousands of hours of families' time. These resources are not only required for the successful implementation of the intervention but also in the preceding advocacy, mobilization, and funding for these services. Given the resources allocated to these efforts, it is understandable that a competitive and controversial atmosphere has developed within the field concerning

which approach is the most effective to reduce ASD symptoms and increase positive outcomes.

As stated above, with increased awareness among practitioners and parents, ASD is being detected and diagnosed earlier and earlier (Lord et al., 2005; Mandell, Novak, & Zubritsky, 2010). This is especially crucial as it is now widely accepted that Early Intervention (EI) programs are indeed beneficial for children with ASD (Boyd et al., 2010; Rogers & Vismara, 2008). Early Intervention has been shown to improve developmental functioning, decrease problem behaviors, and reduce symptom severity (Dawson & Osterling, 1997; Goldstein, 2002; Landa, 2007; Woods & Wetherby, 2003). Although EI is a substantial presence in the ASD literature, there are notably few properly conducted Randomized Controlled Treatment Trials (RCTs) and even fewer comparative studies. Those that have been conducted show both short- and long-term benefits. Despite these investigations, several pressing questions have yet to be clearly answered. Rogers and Vismara (2008) identified three primary areas requiring further investigation: (a) Determining the most effective method of EI; (b) What moderates and mediates treatment gains and long-term outcomes; and (c) Identifying short- and long-term expectations of improvements.

As discussed above, previous studies (Goldstein, 2002; Koegel, 2000) have documented efficacious intervention techniques for individuals with ASD to enhance language and communication skills; however, the necessary components of monitoring the implementation and outcomes are often absent (Lord et al., 2005). Furthermore, a recently convened working group supported by the National Institute of Mental Health (NIMH) tasked to address methodological challenges in research on psychosocial

interventions for ASD drew attention to the *setting* where these interventions are evaluated (Smith et al., 2007). The group called for adjusting the focus from *efficacy* of interventions in controlled treatment studies to *effectiveness* "real-world" investigations in community settings. To successfully implement and disseminate effective interventions, the working group identified four phases for researchers to follow: (a) formulation and systematic application of the intervention method, (b) development of a manual and a predefined plan for the evaluation of the intervention across sites, (c) running randomized clinical trials, and (d) conducting effectiveness studies in real world settings on interventions conducted by community providers (Smith et al., 2007).

The first study, entitled *Comparative Effectiveness of Behavioral and Developmental Approaches in Communication Intervention for Children with Autism Spectrum Disorder*, addressed the first area of need identified by Rogers and Vismara (2008) – determining the most effective method of intervention. This investigation was a preliminary comparison of intervention approaches within the setting of an intensive six-week intervention focused on speech and language skills. This study examined four approaches: Behavioral, Developmental, and two combined approaches. The combined approaches consisted of Behavioral and Developmental strategies presented in one of two orders: Behavioral followed by Developmental (Behavioral-Developmental) or Developmental followed by Behavioral (Developmental-Behavioral). Given the size of the sample, the primary goal of this investigation was to identify strengths and limitations of each, rather than to determine a superior approach. The sample included 26 children (age range: 35-94 months) with a previous diagnosis of ASD which was retroactively confirmed from video with the Childhood Autism Rating Scale, Second Edition (CARS2).

Pretest-posttest between group intervention effects were analyzed using raw scores from the Communication and Symbolic Behavior Scales (CSBS). The CSBS provides measures of nonverbal and verbal communication skills as observed in a semi-structured play interaction. Notable differences between groups were observed on the overall Communication Composite, with the greatest gains made by the Behavioral group (9.56), followed by the Developmental group (7.33), and then the Behavioral-Developmental (5.00) group. The Developmental-Behavioral group had an average *loss* of 2.71 points.

Within group analyses of intervention effects yielded significant results on several clusters and the Communication Composite. As with between group comparisons, the Behavioral group made the biggest gains in 3 clusters as well as the overall Communication Composite. The Behavioral-Developmental group made significant gains in one cluster, and no significant intervention effects were observed within the Developmental or Developmental-Behavioral groups. Reinforcing the importance of early intervention efforts (no matter the approach), significant treatment gains were seen from pretest to posttest in the Communication Composite Score as well as three of the clusters when all four groups were combined.

Overall, our findings from this study were consistent with previous research (Howard et al., 2005) that eclectic or mixed interventions are less effective than a single approach. Although not statistically significant, there were clear group differences observed between the single approaches; the Behavioral group demonstrated multiple significant gains, while the Developmental group did not have any significant gains in communication skills as measured by the CSBS. These results suggest that the

Behavioral approach was better suited for the structure of the 6-week communication intervention, and thus yielded substantial gains in multiple areas.

Addressing the field's call for properly executed *efficacy* studies conducted in community settings, the second and third manuscripts are aimed at the refinement and successful implementation of interventions focused on the needs of individuals in two different stages of development and their respective relevant/crucial areas of focus. As mentioned above, numerous investigations and reviews have demonstrated the benefits of early intervention; however, what remains relatively unknown is whether this progress early in development leads to significant improvements in adulthood. Investigators have noted research on this age group is becoming increasingly critical as the population of adults with ASD increases. As children transition to adolescence and young adulthood, the focus of intervention efforts shift toward promoting adaptive skills that can facilitate and increase independent functioning (Seltzer et al., 2004). Outcomes that are especially important to successful adult outcomes are independence, vocational performance, and social functioning (Rogers & Vismara, 2008; Taylor et al., 2012).

The second manuscript*, Driving Performance in Individuals with Autism Spectrum Disorders: A pilot study investigating the role of executive functioning,* is targeted for this often-overlooked population and aims to assist individuals in the mastery of a skill essential to achieving this independence, driving. The purpose of the second study was to examine differences in driving skills between adolescents and young adults with ASD and non-ASD participants through the use of a Virtual Reality Driving Simulator (VRDS). Additionally, the second study aimed to better understand the role of executive functioning in these differences and overall driving performance with the

ultimate goal of utilizing this information for the refinement of a VRDS training program for individuals with ASD. Although there have been very few research investigations examining driving skills in individuals with ASD to date, available published research have identified this population to be less likely to obtain a drivers license and to demonstrate poorer driving performance than their same-aged peers (Classen & Monahan, 2013; Classen, Monahan, & Hernandez, 2013; Cox, Cox, Reeve, & Cox, 2012; Huang et al., 2012, Reimer et al., 2013, Sheppard, Ropar, Underwood, & van Loon, 2010) stressing the need and relevance of this research.

Previous investigations (Cox, Wharam, Mouran, & Cox, 2009) have demonstrated that novice drivers whose training included the use of a VRDS exhibited more driving skills and were less likely to be in an accident within their first year of driving than those who did not receive VRDS training in addition to routine driver's education. Additionally, the utility of a driving simulator for at-risk populations has been demonstrated in previous investigations (Adler, Resnick, Kunz, & Devinsky, 1995; Brooks, Mossey, Collins, & Tyler, 2013; Hoffman, Lee, Brown, & McGehee, 2002) and driving data collected within the simulated environment has been associated with on-road driving performance (Bédard, Pakkari, Weaver, Riendeau, & Dahlquist, 2010; Shechtman, Classen, Awadzi, & Mann, 2009). Therefore, the VRDS serves to gather important data on this population as well as providing targeted intervention to individuals with ASD who are in the process of obtaining their drivers' license.

Given what we know about deficits associated with ASD and skills required for safe driving, an area of particular interest is *Executive Functioning*. In general terms, executive functioning refers to a cluster of abilities and behaviors (e.g., planning, mental

flexibility, self-monitoring, inhibition of prepotent responses, the use of working memory) that are utilized in order to perform goal-directed actions (Hill, 2004; Ozonoff, Pennington, & Rogers, 1991). Deficits of executive functioning in individuals with ASD have been well-documented in the literature (Hill, 2004; Liss et al., 2001; Ozonoff, Pennington, & Rogers 1991). To better assess and improve these deficits, our research group developed a VRDS training protocol that specifically targets executive functioning skills in the context of driving.

To examine the interrelation between executive functioning and driving performance, we collected data within the VRDS from adolescent and young adult drivers, with and without ASD. Driving performance was measured using two driving simulation paradigms completed by both groups: 1) the assessment of overall driving performance within a simulated driving course (tactical drive); and 2) operational tasks targeting three key executive functioning skills (dual processing, response inhibition, working memory). Overall driving performance was measured using an empirically derived Tactical Driving Composite, which consisted of 14 variables associated with increased vehicular collisions within a normative DMV sample of adult drivers. The three operational scenarios were designed to present an increasing amount of cognitive demands to successfully complete the included tasks. Performance on the operational tasks was measured by number of braking and steering errors made during the three scenarios, as well as the number of signs recalled in the correct serial order during the working memory task.

With regard to basic driving skills, the ASD group did not significantly differ in their performance of combined steering and braking tasks (dual processing), or in braking

reaction time. The ASD did demonstrate significantly slower reaction times to steering tasks, and within our sample, the ASD group was significantly older than the comparison group. However, these factors were not significant covariates of any of the analyses conducted as part of this study. Overall driving performance, as measured by the Tactical Driving Composite, revealed that the comparison group performed significantly better than the ASD group. Maintaining lane position and appropriate distance from ("bumping") the lead car were found to be areas where the ASD group demonstrated the most difficulty compared to the comparison group.

Assessment of executive functioning within driving-relevant tasks revealed there were no significant differences in the number of braking and steering errors made during either the response inhibition or working memory tasks. However, there was a significant interaction observed between group and condition. The increased cognitive demands presented within the working memory task (recalling signs in correct serial order) resulted in a significant one-tailed decrease in steering/braking performance for the ASD group; however, the comparison group demonstrated significantly increased performance with the addition of the working memory task. The groups also differed significantly in the number of signs they were able to recall within the working memory condition – with the ASD group recalling fewer than the comparison group.

Overall, findings from the second study supported previous research indicating that individuals with ASD have difficulty with driving relative to non-ASD peers. This study also identified areas where this population has particular difficulty, especially working memory, which may explain some of the differences observed between drivers with and without ASD. These results serve to provide additional information regarding

the need for further research, as well as the development of driving intervention programs for this population. Furthermore, these findings indicate that individuals with ASD do not demonstrate difficulty with many of the base level aspects of driving (braking, managing braking and steering demands, correctly inhibiting responses based on road demands). Our results suggest individuals with ASD struggle with multiple simultaneous cognitive demands, working memory, and steering and thus provide direction for future research, training, and intervention programming.

The third study, *An Evaluation of Behavioral and Developmental Communication Interventions for Children with Autism Spectrum Disorder,* primarily focused on the feasibility and accessibility of intervention programs. This investigation is an expansion on the first study and was augmented with a more comprehensive battery and two follow-up visits added to track outcomes after the completion of the 2013 intervention program. The battery of child measures and parent questionnaires collected at each time point was expanded to provide more information about communication as well as ASD symptomatology, cognitive abilities, adaptive skills, intervention history, and satisfaction with the program.

The primary aims of this study were to evaluate the feasibility of enrolling, retaining, treating, and tracking outcomes after treatment. Secondary aims were the preliminary examination of treatment outcomes and therapist acceptance of the protocol. The 9 children who enrolled in this 6-week program were randomly assigned to receive either the *Behavioral* or the *Developmental* method of intervention. In addition to the pre-treatment and post-treatment visits, additional clinical and communication measures were collected at 2 and 4 months following the intervention.

This preliminary examination identified high rates of satisfaction, notable treatment gains, and areas of improvement to inform future intervention programming. Feedback from participating families indicated that this intensive communication intervention program was both acceptable and feasible to parents. Parents reported being satisfied with the program, had high attendance rates (91.7%) and completed 89% of the included questionnaires. The cost of the intervention as well as the clarity and amount of requested questionnaires were the most commonly reported potential barriers to participation. Feedback from clinicians was generally positive but suggested the need for modifications to the training protocol to improve clarity and familiarity with the interventions.

The initial treatment outcomes of the speech-language intervention program were promising. Based on parent report and child clinical measures administered at the University clinic, significant gains were reported in word count and notable increases observed in gesture use and non-word vocalizations. Although improvements were observed in these areas, the trajectories differed across the targeted skills and between parent report and clinical measures. Across both measures, the strongest increase was observed in the number of word and word combinations, as measured by the CSBS Communicative Means Verbal subscale and parent-report of word count on the MacArthur-Bates CDI. However there were different patterns of skill development for the two measures. The largest gains on the CSBS were observed from pre-treatment to post-treatment, with minimal change from post-treatment to 4-month follow-up. In contrast, gains observed in the number of words produced, according to parent report on the MacArthur-Bates CDI, were most notable from post-treatment to 2-month follow-up,

with minimal changes reported from pre-treatment to post-treatment or 2-month to 4-month follow-up.

A preliminary, qualitative comparison of the two intervention approaches showed that children who received the *Behavioral* approach tended to demonstrate larger gains on the CSBS subscales while parent-report measures indicated a trend toward overall greater gains by children who received the *Developmental* approach. There were also differences observed in the trajectory of skill development, most notably on the CSBS where there was a trend toward the *Behavioral g*roup showing more gains pre-treatment to post-treatment, whereas the *Developmental* group demonstrated minimal improvement between those first two time points but larger gains from post-treatment to 4-month-follow-up. Based on parent-report on the MacArthur-Bates CDI, the pattern of word and gesture use across the four time points was very similar for both groups with a sharper increase in word count demonstrated by the *Developmental* group, resulting in larger gains overall.

Results from the third study indicate the speech-language intervention program was well accepted by participants with gains in expressive language and gesture use noted during and immediately following the intervention. Feedback from parents and clinicians helped to identify strengths and suggested areas of improvement to help guide future intervention and research efforts with the ultimate goal of conducting larger scale efficacy evaluations and direct comparisons among *Behavioral*- and *Developmental*-based approaches.

The three studies included in this dissertation emphasize the benefits of intervention programming for individuals with ASD as well as the necessity for the

continued development and enhancement of these programs, especially for young children and adolescents. Families, community members, and professionals who work with this specialized population recognize the heterogeneity of the autism spectrum as well as the multitude of interventions available. These investigations represent the initial steps in the development of large-scale empirical studies with the ultimate goal of establishing evidence-based intervention programs to increase access and refine best practices to improve outcomes for children and families affected by ASD.

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Comparative Effectiveness of Behavioral and Developmental Approaches in Communication Intervention for Children with Autism Spectrum Disorder

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Research has demonstrated the importance of early intervention; however, there are few comparative studies investigating the effectiveness of interventions for children with Autism Spectrum Disorder (ASD). In this investigation, we compared effects of Behavioral intervention, Developmental intervention, and a combination of both approaches on 26 children with ASD during four six-week programs targeting communication skills. Analyses of pretest and posttest scores on the Communication and Symbolic Behavior Scales (CSBS) were conducted to measure intervention effects. Between and within group analyses revealed notable differences on Cluster and Communication Composite scores. These findings confirm the importance of early intervention, suggest outcome differences based on approach, and encourage continued collection and further investigation to make conclusions regarding specific strengths intervention methods.

Key Words: Autism Spectrum Disorder, Young Children, Early Intervention, Communication, Language

For over two decades there have been three core symptom clusters for Autism Spectrum Disorder (ASD): deficits in communication, impairment in social reciprocity, and the presence of restricted interests or repetitive behaviors (DSM-IV-TR; American Psychiatric Association, 2000). The newly released Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013) has modified the diagnostic criteria to emphasize *two* core symptom clusters: Social Communication and Restricted Interests and Repetitive Behaviors. Despite these changes, the centrality of communicative deficits in ASD remains consistent, emphasizing the importance of research and clinical programs focusing on this area.

The acquisition and developmental trajectory of early communication skills for children with ASD are notably diverse across the population. Parents often report a delay in expressive language as their first indication of their child's atypical development (De Giacomo & Fombonne, 1998; Wetherby et al., 2004). Research has also shown variability in nonverbal and verbal communication skills among older children with ASD (Charman et al., 2003; Fernell et al., 2010; Matson et al., 2012; Wetherby et al., 2004), leading to a significant number of studies investigating early predictors of language development outcomes (Charman et al., 2003; Mundy, Sigman, & Kasari, 1990; Stone & Yoder, 2001; Thurm, Lord, Lee, & Newschaffer, 2007). It has been demonstrated that cognitive ability (Lord & Schopler, 1989; Sigman et al., 1999), imitation (Stone & Yoder, 2001; Thurm et al., 2007), play skills (McCune, 1995; Ungerer & Sigman, 1984), and joint attention (Dawson et al., 2004; Mundy et al., 1990; Sigman et al., 1999) are predictive of future communication outcomes.

The importance of intensive early intervention has been well documented over the past 30 years (Dawson and Osterling, 1997; Lord et al., 2005; National Research Council, 2001). Numerous studies have been published demonstrating that early intervention efforts can result in improvements in intellectual functioning, behavior, language, and social skills (Dawson & Osterling, 1997; Woods & Wetherby, 2003). Despite this accepted consensus among clinicians and researchers and the continued investigation of intervention approaches, no single approach has been definitively proven as superior. It has been suggested that the effectiveness of one intervention over another may be dependent upon individual characteristics (Zachor & Ben-Itzchak, 2010); however, there are few studies that identify which approach is most effective for which population (Ben-Itzchak & Zachor, 2007; Schreibman, 2000; Turner & Stone, 2007). Furthermore, there have been very few comparisons between two approaches; instead most intervention studies focus on one approach only (Greenspan & Wieder, 1997; Mahoney & Perales, 2003; McEachin et al., 1993), combined ("eclectic") approaches (Eikeseth et al. 2002; Howard et al., 2005; Zachor & Ben-Itzchak, 2010), or standard (educational) intervention programs (Lovaas, 1987; Smith et al., 2000).

More recently, systematic review papers (Eldevik et al., 2009; Goldstein, 2002; Howlin, 2004; Ospina et al., 2008; Rogers, 2008) have been published to help researchers and families wade through decades of published research on intervention and guide practice. These investigations highlight that a true randomized controlled trial (RCT) is a difficult feat for Autism researchers due to several factors. Consistently noted is that given the well-documented benefits of intervention, pure control groups evoke ethical concerns. Additionally, due to the divisions within the field, most researchers who

investigate intervention are biased toward a certain approach and replication is rare. Furthermore, there are very little data on long-term outcomes and trajectories.

There is also a question as to the best way to evaluate intervention effects. Early efforts focused on change in IQ, but this has since been questioned as an accurate measure for this specialized and distinct population (Matson & Smith, 2008). In many approaches, there is an emphasis placed on language and communication. In addition to expressive language delays, nonverbal communication and behaviors such as joint attention, gestures, and requesting are often impaired in ASD (McCathren et al., 2000; Mundy et al., 1990; Sigman et al., 1999; Wetherby et al., 1989; Wetherby et al., 1998). Communication deficits have also been cited by some as a source of problem behaviors (Durand & Merges, 2011; Greenspan & Wieder, 1999), and there is evidence that early communication skills have an influence on trajectory and future outcomes (Dawson et al., 2004; Stone & Yoder, 2001). These findings suggest that change in nonverbal and verbal communication may be an effective method of measuring intervention effects and has been utilized in previous investigations (Cohen et al., 2006; Sherer & Schreibman, 2005).

Families and clinicians have an overwhelming number of Autism intervention approaches to choose from, including but not limited to: speech and language, behavioral, social, developmental, pharmaceutical, sensory integration, and alternative therapies. Often a combination of these approaches is used, targeting the individual needs of the child. This study focuses on two of the most popular approaches: Behavioral and Developmental.

Behavioral approaches are based on the psychological principles of learning theory and operant conditioning. At the core of behavioral approaches is the belief that

human behavior is learned and governed by antecedents and consequences. Therefore, as it applies to children with ASD, individuals can learn new skills by presenting and/or modifying a given stimulus and providing reinforcement. Treatment goals are broken down into discrete steps, which are presented in a determined order that is guided by typical developmental sequences. Behavioral interventions have been implemented to decrease negative behaviors as well as increase language, social, play, and academic behaviors (Schreibman, 2000). These programs are typically one-on-one in clinical or home settings for up to 40 hours per week (Reichow, 2012). Investigations into behavioral approaches dominate the literature; despite methodological differences and varied outcomes, there is clear evidence of the efficacy of this approach. Published studies have demonstrated that behavioral interventions result in increased IQ, adaptive functioning, and language (Eikeseth et al., 2002; Lovaas, 1987; Smith et al., 2000). However, reliable comparisons have not been made between behavioral methods and alternative treatment methods. A primary criticism of this approach is that language and other behaviors taught by this method do not always generalize to other settings due to the highly structured environment and dependence on prompts and reinforcers (Schreibman, 1997, 2000). In response, this approach now frequently emphasizes teaching within a natural (i.e., 'real world') environment.

Developmental approaches (also known as relationship-based) focus on enhancing interactions and fostering relationships between the child and parent (or other involved individuals) by facilitating positive exchanges and promoting reciprocity. Previous research has supported the relational foundation for this approach, demonstrating that increased synchrony and responsive interactions by parents result in

increases in communication skills (Siller & Sigman, 2002). As it applies to this population, the developmental impairments associated with Autism Spectrum Disorder affect a child's ability to connect with others, specifically caregivers, resulting in fewer positive, reciprocal interactions. Asserting that key emotional, social, and language skills are obtained through these interactions, this approach promotes these exchanges by following the child's lead. Although commonly utilized in clinical practice and partially developed out of criticisms of intensive behavioral interventions, there are notably fewer published studies on developmental, relationship-based approaches. Available published studies on developmental intervention programs have shown increases in emotional, social, cognitive, and language functioning (Greenspan & Wieder, 1997; Rogers et al., 2000; Solomon et al., 2004). A commonly cited advantage of this program is that it is easier for nonprofessionals to learn, and responses are more easily generalized to other contexts. In addition to noting the small body of literature, criticisms of this approach have addressed the variation of administration due to a lack of set protocols and differences between individual therapists (Zachor et al., 2007).

The current study aims to make a direct comparison of behavioral and developmental approaches to speech and language intervention within a clinical setting. In addition to providing crucial clinical services, the successful communication intervention program detailed below contributes valuable data to the field by utilizing the foundational principles of two of the most popular approaches within a real-world setting. Rather than determine a superior approach, the ultimate goal of this continued investigation is to identify strengths and limitations of each. Although our sample size is small, we hope future research and continued data collection from this intervention

program will provide insight into which ASD profiles are best served by which approach, and will better define changes observed within and between groups.

Methods

Participants

Thirty-seven children between 35 and 94 months of age participated in the intervention program during the summers of 2008, 2009, 2011, and 2012. Four of these individuals returned to the University for a second intervention program; data collected from their second enrollment was not included in the dataset. Additionally, one individual did not complete the intervention, and was also excluded from the sample, resulting in a total sample of 36. For all summer programs, children with ASD were identified from the communities surrounding the University by local service providers, (e.g., Speech and Language Pathologists and early intervention providers), who were provided with materials to distribute to interested families. Additionally, eligible families who were seen at the University clinic for speech or assessment services were given information about the summer program. Inclusion criteria included: a documented diagnosis of ASD, between 2 (2:0) and 10 (10:0) years of age, English as a primary language, no other co-morbid developmental, genetic, or psychiatric diagnoses (such as Attention-Deficit/ Hyperactivity Disorder, Fragile X syndrome, or Tourette Syndrome), informed consent by parent and assent by subject (if applicable), and stated willingness to complete the project.

Intervention Design and Procedures

Following pretest sessions (week 1), all participants received three-hour intervention sessions, four days per week for six consecutive weeks (weeks 2-7), then

posttest sessions (week 8). Each intervention session consisted of three 50-minute blocks of intervention, with 10-minute breaks between each block. For all four summer programs, children were matched on pre-intervention variables (detailed below) then randomly assigned to one of two intervention groups offered that year. The 2008 and 2009 participants were assigned to one of two combined interventions, with each 50-minute block including 25 minutes of each intervention, in one of two orders: Behavioral followed by Developmental (Behavioral-Developmental) or Developmental followed by Behavioral (Developmental-Behavioral). The 2011 and 2012 participants were randomly assigned to either Behavioral Only or Developmental Only sessions.

Intervention approaches. Both Behavioral and Developmental approaches were designed with goals established to focus on speech and language skills. These goals were broken down into separate steps then sequentially taught to each child. The Behavioral intervention involved a behavior modification approach for increasing desired behaviors. The steps of the Behavioral program included: 1) Child chooses reward; 2) Antecedent (stimulus) is presented; 3) Behavior is observed and child is prompted if necessary; 4) Reinforce behavior with token; 5) Provide reward after 10 tokens. The Developmental intervention involved following the child's actions and expanding their communication to increase desired behaviors. Children who received Developmental sessions had access to the same toys, materials, media, and activities as those who received the Behavioral intervention; however the children were allowed to direct the session by selecting which activity to begin. The steps of the Developmental program included: 1) Observe child's behavior; 2) Open circle of communication; 3) Follow the child's lead; 4) Expand or extend; 5) Close circle of communication.

Group assignment. In order to control for internal validity threats from possible variation between the subjects, participants were carefully screened and paired before being randomly assigned to the one of the two intervention groups offered each year. Participants were manually matched as closely as possible on several criteria: chronological age, pretest communication skills, functional language stage, and intervention history. These evaluations were based on information forms completed by parents and pretest observations by the Clinical Director, a certified Speech and Language pathologist with over twenty years experience working with children on the Autism Spectrum. Although all participants had previously received diagnoses of Autism Spectrum Disorder, diagnosis was retroactively confirmed from video for research purposes.

Clinician training and scheduling. In the month prior to the start of the intervention, qualified graduate students from the University Speech and Language Pathology program were identified and underwent a two-week training, covering both methods of intervention. The selected student clinicians had approximately equivalent experience with children diagnosed with ASD. The Clinical Director, who had experience in both Behavioral and Developmental intervention approaches, supervised all student trainings with the assistance of Clinical Instructors. Clinical Instructors had obtained a Masters degree in Speech and Language Pathology and had received a Certificate of Clinical Competence. All student clinicians received an introductory training packet that included relevant literature on each approach and the steps (outlined above) to be followed during the sessions. The Clinical Director and the Clinical Instructors reviewed these steps in live training sessions and assessed each student

clinician for adherence to the treatment protocols. During the training period, the clinicians' progress was monitored as they practiced each approach with other student clinicians as well as supervising Clinical Instructors. Training was completed when all supervising instructors agreed that the student clinician implemented the steps of each program correctly in these practice settings with 90% accuracy across three consecutive sessions.

Student clinicians were then scheduled so that all participating children had equal time with each clinician, and all student clinicians administered both methods of intervention equally over the six weeks of intervention. One treatment block (50 minutes) of each three-hour intervention session was monitored by a Clinical Instructor or a "floating" student clinician (not assigned to work with a child for the current block). These observers monitored clinicians' performance in one of two areas, on alternating weeks: (1) adherence to steps, and (2) data collection. Thus, one-third of every intervention session was reviewed to corroborate accurate data collection *or* proper implementation of the assigned intervention approach.

Measures

In order to evaluate relative effectiveness of the two approaches, pretest and posttest results on the Communication and Symbolic Behavior Scales (CSBS; Wetherby & Prizant, 1993) were compared following their enrollment in a six-week program. The CSBS is a widely accepted diagnostic protocol designed to be used with children demonstrating a "functional communication age between 8 months and 2 years" (Wetherby & Prizant, 1999, p. 1). The CSBS measures 22 factors related to communication that fall into seven communication Clusters: Communicative Function,

Communication Means-Gestural, Communication Means-Vocal, Communication Means-Verbal, Reciprocity, Social-Affective Signaling, and Symbolic Behaviors. Additionally, constructive and symbolic (pretend) play behaviors are assessed by the CSBS. During CSBS administration, the examiner allows the child to use communication skills in a natural environment by prompting and responding to the communication initiated by the child. The CSBS calculates scores based on the types of interactions a child demonstrates during the administration (e.g., behavior regulation, joint attention, and sociability of communication function) as well as patterns of interaction with toys, caregivers, and examiners. A Communication Composite score is calculated from six of the Cluster scores (does not include the Symbolic Cluster).

The Childhood Autism Rating Scale, Second Edition (CARS2; Schopler et al., 2010) rating form was completed for all participants to assess the presence and severity of ASD symptoms and to confirm diagnosis for research purposes. The CARS2 (and the original publication, CARS) is a widely used and empirically validated autism assessment (Schopler et al., 2010). The CARS2 consists of 15 domains, with 14 assessing behaviors associated with ASD, and the final domain rating general impressions of ASD diagnosis. Domain score ranges from 1 to 4, with higher scores associated with a higher level of impairment. Total scores can range from 15 to 60; scores below 30 indicate "Minimal-to-No" symptoms of ASD, scores between 30 and 36.5 indicate "Mild-to-Moderate" symptoms of ASD, and scores from 37 to 60 indicate "Severe" symptoms of ASD (Schopler et al., 2010). The CARS2 has two rating booklet forms: Standard Version and High Functioning Individuals. The Standard Version was used for this investigation because of the age and significant expressive language delays demonstrated by all

children participating in the program. Because the amount of background information gathered from parents varied from year to year, and was often dependent on whether the child was enrolled in school (and IEP reports were available), rating forms were completed based upon video recordings of the CSBS administered at pretest. Two clinical psychology doctoral students completed the CARS2 ratings for the sample of 36 children; reliability statistics were calculated in a randomly selected subset of the sample (n = 12). The agreement between raters for CARS2 total scores was high (r (10) = 0.88), and a kappa analysis assessing the level of agreement between two raters in regard to overall CARS2 classification (e.g., Autism or Non-Autism) produced a kappa of .68 (p = .01), indicating substantial agreement. Raters independently assessed 12 participants in addition to those 12 that were double-coded, totaling the sample of 36.

Results

Between group intervention effects were analyzed by performing ANCOVAs on posttest Cluster and Communication Composite scores from the CSBS, using pretest scores as a covariate. Intervention effects within groups were assessed using dependent t-tests. Because the sample consisted of children with varying expressive language abilities, raw scores were used so comparisons could be made across CSBS language stages. Based on the retroactively completed CARS2 ratings, 10 of the 36 children enrolled in the four summer programs demonstrated "Minimal-to-No" symptoms of an Autism Spectrum Disorder (< 30), and were eliminated from the sample. The resulting sample consisted of 26 children: 9 received Behavioral Only (mean age= 51.89 months), 6 received Developmental Only (mean age=56.50 months), 4 received Behavioral-Developmental (mean age=67.00 months), and 7 received Developmental-Behavioral (mean age=60.57

months). Results were analyzed across three and four groups, creating a combined group for both Behavioral-Developmental and Developmental-Behavioral and also separating them. In addition to creating a more balanced design, using four groups produced more clear group differences than three groups, therefore results will be reported using four groups.

Although between group differences were observed from pretest to posttest on several of the seven Clusters and the Communication Composite, illustrated by the mean change in raw scores reported in Table 1, none of these were statistically significant. Although not significant, notable differences between groups were observed on the Communication Composite, which represents a total score, with mean raw score gains of: 9.56 points (SD=8.55) observed in the Behavioral group, 7.33 points (SD=10.03) in the Developmental group, and 5.00 points (SD=3.16) in the Behavioral-Developmental group. The Developmental-Behavioral group had an average loss of 2.71 points (SD=8.94).

Within group analyses of intervention effects yielded significant results on several Clusters and the Communication Composite, with large effect sizes as illustrated in Figure 1. Within the Behavioral group, significant gains were observed in the Communicative Means-Vocal (M=3.11, SD=2.37; t(8)=3.94, p=.004, *d*=1.71), Communicative Means-Verbal (M=1.44, SD=1.51; t(8)=2.87, p=.021, *d*=1.11) and Reciprocity (M=1.56, SD=2.01; t(8)=2.33, p=.049, *d*=0.82) Clusters as well as in the Communication Composite Score (M=9.56; SD=8.55; t(8)=3.36, p=.01, *d*=1.30). Within the Behavioral-Developmental group, significant gains were observed in the Communicative Means-Gestural Cluster (M=1.25, SD=0.96; t(2)=5.00, p=.015, *d*=2.31).

No significant intervention effects were observed within the Developmental Only or Developmental-Behavioral groups.

Discussion

Given the heterogeneity of the clinical phenotype and numerous intervention approaches available, there are currently no prescribed interventions for specific profiles of ASD. The goal of this investigation was to preliminarily identify strengths and limitations of Behavioral and Developmental approaches rather than identify one as superior. Overall, our findings were consistent with previous research (Howard et al., 2005), indicating that mixed interventions are less effective than a single approach. As expected, gains in the Behavioral Only and Developmental Only approaches were higher than the treatment effects observed in the Behavioral-Developmental and Developmental-Behavioral groups. These findings ultimately led to our decision to discontinue combined intervention programs, and subsequent summer programs will only consist of individual approaches: Behavioral Only and Developmental Only.

Although not statistically significant, there were observable group differences seen between the single approaches: the Behavioral group demonstrated multiple significant gains, while the Developmental group did not have any significant gains in communication skills as measured by the CSBS. These results suggest that the Behavioral approach and token reward system was better suited for the structure of the six-week communication intervention program, and thus yielded substantial gains in multiple areas. Additionally, there were stark differences between the two combined approaches, with the Developmental-Behavioral group showing mean losses across several CSBS Clusters, and the Behavioral-Developmental group demonstrating

significant gains in one area. Although these Cluster mean losses warrant further investigation, we propose that the losses seen in the Developmental-Behavioral group may be due to the nature of the interventions themselves. Children in this group would have started each of the three daily 50-minute session with less structure in the Developmental format and then had structure imposed upon them in the second half of the block with the Behavioral approach. It is therefore possible that a portion of their sessions were in turn devoted to this transition rather than skill-building

Limitations

There are several limitations to consider when interpreting results from this study. First, our overall and group sample size, especially after eliminating those who did not meet criteria on the CARS2, was relatively small which affected the power of the statistical analyses. Additionally, when duplicate participants were eliminated, we were left with an unbalanced design that may have affected analyses. It is important to note that our subject eliminations based on the CARS2 were conservative as they were based solely on video from the CSBS at pretest, which was coded retroactively in 2013 for all years. Therefore, we likely eliminated several children who would have met criteria for ASD at the time of the intervention based upon parent report measures.

As has been the case for many studies on intervention approaches, the nature and typical guidelines of each approach also serve as limitations. First, the loose guidelines for the Developmental approach caused the sessions to vary depending on the child's actions; therefore, by the nature of the approach, its administration was not entirely in the clinician's control. Also, Behavioral approaches emphasize the importance of intensive intervention, often for as much as 30-40 hours per week. Given the constraints of this

study those weekly quotas were not met, nor was an at-home program in place. However, these limitations would have impacted the effectiveness of both programs and therefore the comparison can still be made. Across the three summer sessions, the graduate students selected as clinicians were given identical training and their administration was monitored. Though these protocols were in place, since different students were selected for each summer program, administration may have varied slightly from year to year.

It is important to consider these limitations when reviewing results from this study; however these limitations do not outweigh the implications that can be drawn for ASD intervention efforts. As this program was conducted within a University clinic, many of these restrictions mirror those that would be expected in this setting. This initial inquiry serves to inform practicing clinicians in the development and implementation of successful intervention programs for children with ASD.

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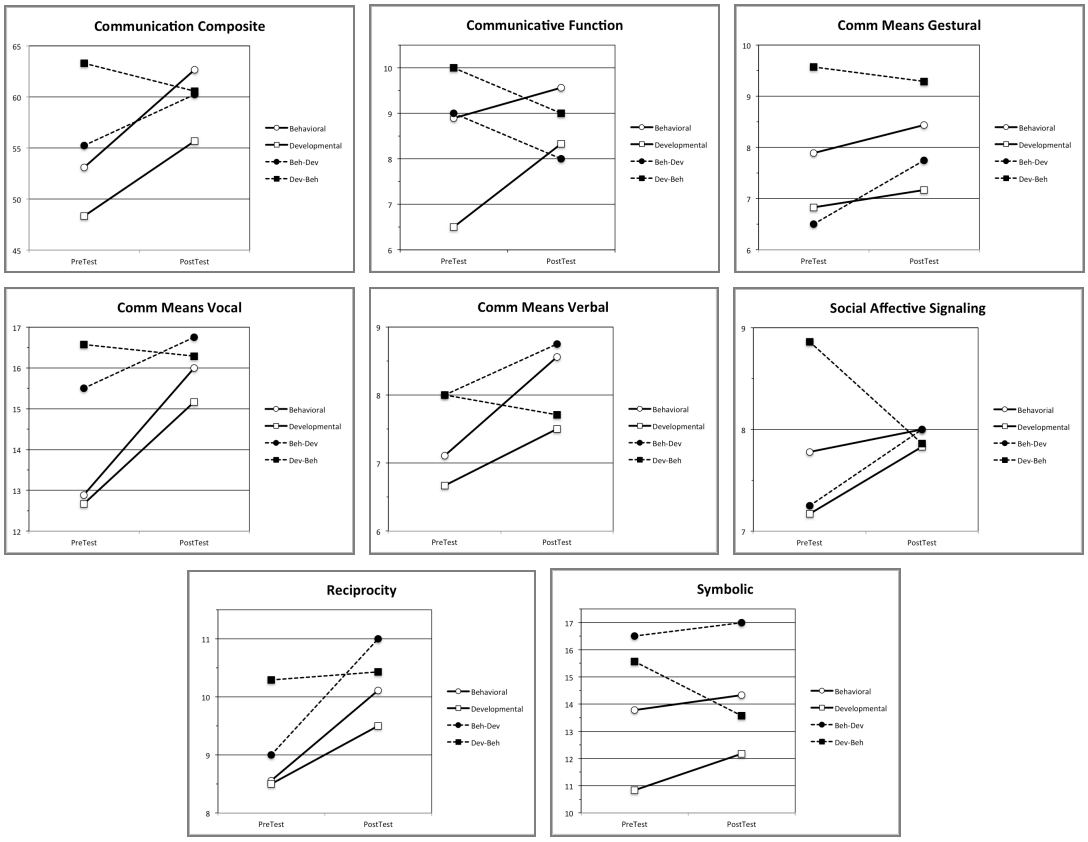
Table 1. *Mean Differences from Posttest to Pretest on Cluster and Composite Scores of CSBS by Group.*

	Behavioral (N=9)		Developmental (N=6)		Beh-Dev (N=4)		Dev-Beh (N=7)	
CSBS Cluster	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Comm. Function	0.67	2.35	1.83	2.48	-1.00	1.41	-1.00	2.31
Comm. Means Gestural	0.56	2.19	0.33	2.42	1.25*	0.50	-0.29	1.38
Comm. Means Vocal	3.11*	2.37	2.50	2.43	1.25	0.96	-0.29	1.80
Comm. Means Verbal	1.44*	1.51	0.83	1.72	0.75	0.96	-0.29	0.95
Reciprocity	1.56*	2.01	1.00	1.41	2.00	1.63	0.14	3.34
Soc-Aff Signaling	0.22	2.39	0.67	2.42	0.75	0.96	-1.00	1.91
Symbolic	0.56	1.88	1.33	2.66	0.50	1.91	-2.00	2.45
Comm. Composite	9.56*	8.55	7.33	10.03	5.00	3.16	-2.71	8.94

* $p<.05$; ** $p<.001$

Figure 1. *Mean Pretest and Posttest CSBS Cluster and Communication Composite Scores by Group.*



Driving Performance in Individuals with Autism Spectrum Disorders:

A pilot study investigating the role of executive functioning

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Autism is a neurodevelopmental disorder that affects socialization, communication, and behavior. Autism Spectrum Disorders (ASD) is a term used to refer to a group of Pervasive Developmental Disorders that include: Autistic Disorder, Asperger's Syndrome, and Pervasive Developmental Disorders, Not Otherwise Specified (PDD-NOS; Diagnostic and Statistical Manual of Mental Disorders; DSM-IV TR, American Psychiatric Association; APA, 2000). Three core features characterize ASD: deficits in communication, differences in socialization, and the presence of repetitive behaviors and/or restricted interests. The newly released DSM-5 (APA, 2013) has modified these criteria, combining communication and socialization into one category. Additionally, the subdiagnoses listed above have been eliminated, leaving a singular "Autism Spectrum Disorder." It is still unclear how these changes will impact diagnosis and prevalence rates, but with the most recent estimate of 1 in 68 births (Baio, 2014), awareness is increasing and additional resources are being devoted to this specialized population.

While many individuals with ASD have secured a driver's license, and there currently are no data available on accident rates, informal reporting suggests that the acquisition of safe driving skills is difficult for this population (Classen, Monahan, & Hernandez, 2013; Cox, Cox, Reeve, & Cox, 2012; Huang, Kao, Curry, & Durbin, 2012). Due to the heterogeneity of symptom severity and phenotypic presentation, many of these individuals may be able to learn to safely operate a motor vehicle. Training drivers with ASD not only increases their independence but, given rising prevalence rates, is relevant to public safety.

ASD & Driving

Research investigating driving skills of individuals with ASD has emerged in the literature within the past 5 years. These studies have revealed that individuals with ASD demonstrate increased anxiety, deficits in hazard perception, differences in visual attention, and overall poorer driving performance than non-ASD drivers (Classen & Monahan, 2013; Classen, Monahan, & Hernandez, 2013; Cox et al., 2012; Huang et al., 2012, Reimer et al., 2013 Sheppard, Ropar, Underwood, & van Loon, 2010)

A review of the literature by this author, as well as an evidence-based review by Classen and Monahan (2013), revealed an emerging body of research focusing on driving performance of individuals with ASD. Sheppard and colleagues (2010) were the first to specifically investigate this critical topic. Based on the established knowledge that individuals with ASD have difficulties interpreting social information, the study compared the abilities of young non-driving adults with and without ASD to identify both social and non-social driving hazards presented through video clips, recorded from the viewpoint of the driver. Participants with ASD identified fewer social hazards and exhibited slower response times than comparison participants; however, there were no significant between group differences in the detection of non-social hazards.

Two later investigations utilized driving simulation environments to assess driving performance. Reimer et al. (2013) collected physiological measures (skin conductance, heart rate, and eye tracking) during a simulated driving scenario. In addition to successfully completing a drive on the simulated highway, participants were asked to perform two previously learned tasks while driving: a hands-free cellular phone task and an auditory continuous performance task (CPT). Compared to age-matched community

controls, when presented with increased cognitive demands, participants with ASD showed a "higher" gaze pattern that indicated they were looking away from objects low in their visual field (i.e., dashboard, on-coming vehicles). Additionally, participants with ASD displayed higher and less varied heart rate compared to age-matched community controls, suggesting increased levels of anxiety. A subsequent study by Classen and colleagues (2013) used a driving simulator to assess driving skills as well as administering a battery of clinical tests measuring visual, motor, and cognitive abilities. Compared to age-matched healthy controls, adolescents with ASD demonstrated lower performance in all areas, with significant differences observed in right eye visual acuity, motor coordination, and several simulated driving skills—speed regulation, lane maintenance, signaling, and adjustment to stimuli.

In addition to experimental studies, two survey studies have recently been conducted to identify the characteristics of driving and non-driving adolescents with ASD. These provide insight into the driving experience for individuals with ASD and their families. Huang et al. (2012) utilized an online research registry to conduct an online survey comparing characteristics of driving and non-driving adolescents with ASD across a variety of areas: diagnostic, demographic, education, employment, and driving training. Compared to age-eligible non-driving teens with ASD, a greater number of driving teens with ASD were in full-time regular education programs, planned to attend college, and had previously held a paying job. Parent experience teaching teens to drive as well as identified driving goals within Individualized Education Plans predicted driving status. Our research group (Cox et al., 2012) also conducted an online survey with parents/caregivers of adolescents and young adults with ASD who were currently

attempting or previously attempted to learn to drive. Just under half (48%) of the respondents reported that their son/daughter had successfully obtained their drivers' license, 29% had acquired their learners' permit, 8% were pursuing a permit, and 15% were not presently pursuing a permit or license. Parents/caregivers primarily (46%) identified a lack of interest as the main reason for not pursuing a permit/license, 19% identified ASD as the primary reason, and 12% reported they (parents) would not give their permission. Respondents were also asked to rate the impact of seven characteristics often associated with ASD on their son/daughter's driving skills. "Difficulty with multitasking" was most frequently endorsed as impacting driving skills and also was identified as the most difficult driving skill for respondents to teach their son/daughter.

Virtual Reality Driving Simulator Assessment & Training

As affirmed by the research studies outlined above, driving safely is a difficult and complex skill, not easily developed by all novice drivers. Indeed, motor vehicle crashes are the leading cause of injury and death among 16-19-year-olds in the United States (Simons-Morton & Ouimet, 2006). Furthermore, vehicle crashes are significantly higher among adolescents in the first year of licensure, with declining rates as more experience is acquired (Simons-Morton & Ouimet, 2006). As outlined in two of the studies mentioned above (Classen at al., 2013; Reimer et al., 2013), one promising solution to the dangers associated with on-road training is use of driving simulators. Such simulators can provide driving experience similar to real world driving without endangering the lives and safety of young drivers and others on the road with them. Our research group (Cox, Wharam, Mouran, & Cox, 2009) has previously demonstrated that novice drivers whose training included the use of a virtual reality simulator were

consistently more skilled across a variety of driving tasks than matched controls who only received on-road training (as rated by state-certified driving evaluators blind to driving training condition); these individuals were also less likely to be involved in an accident in their first year of driving independently. Learning these skills within a simulated environment has been shown to be beneficial for at-risk populations (Adler, Resnick, Kunz, & Devinsky, 1995; Brooks, Mossey, Collins, & Tyler, 2013; Hoffman, Lee, Brown, & McGehee, 2002). Previous studies have also demonstrated that errors recorded during simulator evaluations are related to errors assessed during on-road testing (Bédard, Pakkari, Weaver, Riendeau, & Dahlquist, 2010; Shechtman, Classen, Awadzi, & Mann, 2009). Thus, these valuable data can be utilized for the development of intervention programs for at-risk populations.

Executive Functioning

Executive function refers to a cluster of abilities and behaviors (e.g., planning, mental flexibility, self-monitoring, inhibition of prepotent responses, use of working memory) needed to perform goal-directed actions (Hill, 2004; Ozonoff, Pennington, & Rogers, 1991). Interestingly, the maturation of executive functioning in typically developing individuals parallels the decline in vehicular collisions; both plateau around age 25 (National Highway and Transportation Safety Administration, 2008; Zelazo, Craik, & Booth, 2004). Additionally, lower levels of executive functioning have been associated with higher frequency of vehicular collisions, and groups at high risk for vehicular collisions (such as those diagnosed with ADHD) have been previously identified to have lower levels of executive functioning (Banich, 2004; Barkley, Lambert, Simons-Morton, Cain, Weisz, & Cox, 2014; Murphy, Dupaul, & Bush, 2002).

Deficits of executive functioning in individuals with ASD have been well-documented in the literature (Hill, 2004; Liss et al. 2001; Ozonoff et al. 1991). It has also been proposed that many ASD symptoms are associated with deficits in executive functioning, such as theory of mind, as well as diminished abilities to anticipate consequences, inhibit impulses, plan ahead, and problem solve (Banich, 2004; Hill, 2004; Ozonoff et al., 1991). It is speculated, and quite conceivable, that such deficits may contribute to driving problems for individuals with ASD, but little is known about *how* these features affect driving performance (Classen & Monahan, 2012). Understanding the mechanisms and processes underlying adverse driving outcomes from this population is critical to designing and assessing driving training programs and accommodations for this population.

Rationale, Significance, and Purpose

Driving is an important milestone for adolescents and young adults, and a critical step toward independence (Monahan, 2012; Womack & Silverstein, 2012). Although little is known about driving abilities of individuals with ASD, previous studies have identified this population to be less likely to obtain a driver's license and to demonstrate poorer driving performance than their same-aged peers (Classen et al. 2013; Cox et al. 2012). The virtual reality simulator offers an ideal, safe environment to assess and provide targeted intervention to individuals who are in the process of obtaining their drivers' license (Adler et al. 1995; Brooks et al. 2013; Hoffman et al. 2002).

The purpose of this study is to examine differences in driving skills between adolescents and young adults with ASD and non-ASD participants through the use of a Virtual Reality Driving Simulator (VRDS). Additionally, this study aimed to better

understand the role of executive functioning in driving differences and overall driving performance for individuals with ASD. This goal was achieved with the use of two driving simulation paradigms completed by both groups: 1) the assessment of overall driving performance within a simulated driving course (tactical drive); and 2) a set of operational tasks assessing executive functioning skills (dual processing, response inhibition, working memory) within driving relevant scenarios. These findings will serve to shape future empirical studies investigating driving skills in individuals with ASD as well as inform the development of targeted intervention programs for this population.

Methods

Participants & Simulator Design

Participants

Subjects were 44 male adolescents and young adults, 17 with ASD and 27 healthy controls. Adolescents and young adults in the ASD group were between the ages of 15 and 23, had their driving permit, and had previously received a DSM-IV (APA, 2000) diagnosis of an Autism Spectrum Disorder (Autistic Disorder (n=4), Asperger Syndrome (n=7), PDD-NOS (n=3)). A community sample was selected for comparative purposes from another study conducted at the University of Virginia. This concurrent study focused on new drivers; therefore, all comparison participants had recently obtained their drivers' license. All ASD participants identified their ethnicity as White/Caucasian; of the comparison sample, two participants' ethnicity were Asian/Pacific Islander, one was Hispanic, one preferred not to respond, and the remaining were White/Caucasian (Table 1).

For the ASD group, a diagnosis of ASD was verified by parent report using the Social Responsiveness Scale (SRS; Constantino & Gruber, 2002) or the Social Responsiveness Scale-Second Edition (SRS-2; Constantino & Gruber, 2012). The newer version of this widely used diagnostic measure was administered to subjects enrolled in the study after January, 2013 (n=8). ASD subjects were recruited for a larger driving training study, with data collected pre- and post- intervention; this manuscript utilized only pre-intervention data.

The Institutional Review Board at the University of Virginia approved both studies and all participants signed an informed consent form, participants under age 18 signed an assent form and a parent signed a consent form.

Simulator

We employed the commercially available Driver Guidance System (DGS-78), a mid-level driving simulator (Figure 1). This simulator displays a 210° field of view on a curved screen inside an 8 foot cylinder. The simulator includes seatbelt, dashboard, steering wheel, turn signal, gas and brake controls, right, left, side, and rearview mirrors, as well as an adjustable seat. A unique capability of this simulator is that it evaluates a battery of operational driving *abilities* and driving *skills* using two stages: operational tests and a tactical driving scenario.

The operational tests paralleled basic neuropsychological tests, with the use of driving-relevant stimuli, requiring driving-relevant responses, in a driving context. The tactical test involved driving 5 miles of rural, 6 miles of highway, and 4 miles of urban roads, negotiating routine driving events (e.g., stop lights, stop signs, speed limit changes) and unanticipated events that require defensive braking (e.g., parked car pulling

into driver's lane; cross-traffic motorcyclist pulling into driver's path) and defensive steering (e.g., oncoming car swerving into driver's lane; rear approaching bicyclist while turning right). The following four classes of driving variables were monitored and summed into a composite score: braking, speed control, steering, and judgment. All participants completed the operational tests prior to the tactical driving scenario; the duration of the tactical course varied depended on the driver's accuracy and efficiency in completing the course.

Psychometric evidence supports the reliability and validity of the simulator tasks, including 2-week test-retest reliability of .86 (tactical composite), a large normative sample (N = 455), discriminant validity for differentiating experienced from novice drivers, and concurrent validity of the simulator executive functioning tasks with established executive functioning tests (D-KEFS r = .51 to .71; Cox, 2014). The tactical composite score significantly predicted future collisions (Cox, Taylor, & Kovatchev, 1999), and performance on the simulator parallels on-road driving (Cox & Cox, 1998).

Driving Simulator Procedure

Motor tasks/response contingency training. In this first scenario, each driver was required to process and employ two driving instruction goals presented in two separate training tasks to create response prepotency prior to the inhibition task. For both tasks, the driver followed a lead vehicle at a fixed speed, distance, and lane position. The first goal was braking; during this scenario, the lead vehicle's brake lights came on 10 times periodically for short (0.5 seconds) or long (3 seconds) durations. Drivers were instructed to remove their foot from the accelerator and press the brake as soon as both short and long brake lights were detected. Following the braking task, drivers engaged in a steering

task. During this task, the lead vehicle's rear wheels passed over six "filled" potholes that were gray and six "unfilled" potholes that were black, three of each from beneath the left wheel and three of each from beneath the right wheel. Drivers were instructed to avoid both filled and unfilled potholes by steering around the potholes without leaving their lane. The primary purpose of these two tasks was to create prepotent responses to the dependent variables that were assessed later in the response inhibition and working memory tasks. Additionally, reaction times for all steering (hand/arm coordination) and braking (foot/leg coordination) trials were recorded. Drivers completed ten trials of braking followed by twelve trials of steering, presented at jittered intervals (i.e., varied duration between trials).

Executive Function Test 1 - Dual processing task. In this scenario, the braking and steering tasks were combined, such that drivers were required to attend and respond concurrently to brake lights *and* potholes. Drivers completed a total of 16 braking and steering trials (8 of each), presented in a standardized order at jittered intervals during this second operational test. The dual processing task served to further establish response prepotency in preparation for the inhibition task described below. The dependent variable of interest in this task was total percentage of correct responses, which includes percentage correct brake responses (braking in response to short and long brake lights) and percentage correct steering responses (steering in response to filled and unfilled potholes).

Executive Function Test 2 - Response inhibition test. *Response inhibition* refers to the ability to suppress the processing, activation, or expression of information (or action) that would otherwise interfere with the attainment of a desired cognitive or

behavioral goal (Dagenbach & Carr, 1994; Dempster, 1992). This third operational test required drivers to inhibit 2 of the 4 previously trained prepotent responses. This time, they were instructed *not* to press the brake when the brake lights came on for a short duration and only press the brake in response to long brake lights. Similarly, participants were instructed to ignore filled potholes by refraining from steering around them, but to continue to steer around unfilled potholes. In this scenario, all drivers completed 16 braking and steering trials (8 trials of each), presented in standardized order at jittered intervals.

The dependent variable of interest was the percentage of total correct responses, comprised of correct braking responses (braking in response to long brake lights, not braking to short brake lights) and correct steering responses (steering in response to unfilled potholes, not steering in response to filled potholes).

Executive Function Test 3 - Working memory test. *Working memory* is a limited capacity system responsible for the temporary storage, rehearsal, updating, and mental manipulation of information for use in guiding behavior. Working memory has been linked to a number of real world skills including driving (Cohen & Conway, 2008). The working memory operational test was modeled after the automated operation span task (Conway et al. 2005; Unsworth, Heitz, Schrock, & Engle, 2005) to provide an index of overall working memory functioning. Thus, it is a complex span task that requires participants to hold an increasing quantity of information (road signs) while simultaneously performing an attention-demanding secondary processing task (inhibit/not inhibit steering/braking) that places demands on the same stimulus modality (visual). This test built upon the previous tests by requiring the participant to remember presented

road signs while adhering to the response inhibition instructions from the previous scenario. Drivers were given the same instructions as the response inhibition scenario. In addition, they were told they would be passing common road signs and were instructed to remember these signs in the order presented for a later test. There were 18 unique nonverbal standard road signs (e.g., Airport, Hospital, Library) presented randomly. After passing a series of signs (ranging in number from 1 to 3), the driving simulator would automatically pause, and the driver would be presented with an array of the 18 signs on the simulator screen. The driver would then be asked to identify the signs, in the same serial order, they had passed since the last series. The working memory scenario consisted of 26 braking and steering trials, presented at jittered intervals. A total of 9 series of 1-3 road signs per series were presented at jittered intervals. The dependent variables of interest were percentage of total correct responses during the driving task (same DV as described for the response inhibition test upon which the working memory test is built), and the number of road signs recalled in the correct serial order (out of 18 possible).

Operational Composite. An Operational Composite was calculated using the average z-score from six variables listed above: braking reaction time, steering reaction time, number of signs recalled, and total correct responses from the dual processing, response inhibition, and working memory scenarios; higher scores indicate better driving performance. Z-scores for each variable were computed twice: once based on the current sample for the study's primary analyses, and separately relative to the Virginia Department of Motor Vehicles (DMV) VRDS normative sample (448 adults, ages: 25-70;

Cox, 2014) to provide additional insights into the driving performance of both groups relative to experienced drivers (presented in Table 2).

Tactical driving test. The tactical driving test monitored 31 performance variables, such as swerving, rolling stops, speeding, and collisions. Fourteen of these 31 variables were selected *a priori* based on evidence from the DMV normative sample (Cox, 2014) that they significantly predict on-road accident rates. These 14 variables were grouped conceptually into four primary skill areas: braking, speed control, steering, and judgment. Braking variables included: Rolling Stops (ratio of incomplete [>0 and <5 mph] to complete [0 mph] stops), Deceleration Smoothness (total magnitude of rapid decelerations; i.e., slamming on brakes), Collisions (number of collisions with another vehicle > 5 mph), and Bumps (number of collisions ≤ 5 mph). Speed control variables included: Acceleration Smoothness (total magnitude of rapid accelerations; i.e., slamming on gas), Speed Plus 5 MPH (total time spent driving 5-19 mph above the posted speed limit), Speed Plus 20 MPH (total time spent driving 20+ mph over the posted speed limit), and Tailgating (number of times driver is within 15 feet of lead car in open road condition). Steering variables included: Lane Position Variability (standard deviation of lane position; i.e., swerving); Midline (average magnitude active; composite score of how far across and for how long driver was in oncoming lane of traffic), Off Road (standard deviation time active; variability of time driver drove off road), and Off Road Resets (number of times driver failed to make a turn when instructed, requiring a reset to designated route). Judgment variables identified were: No Signal for Lane Change (number of lane changes without using turn signal) and Speed Minus 20 MPH (average time spent 20 mph or more under the posted speed limit).

An overall Tactical Driving Composite was computed from these variables and served as the primary indicator of driving performance. This composite was calculated as an average of the z-scores across the 14 variables. Mean z-scores reflect standard deviations from the normative sample mean; positive and negative values indicate better and worse performance relative to the normative sample of experienced drivers, respectively. Z-scores for each variable were computed twice: once based on the current sample for the study's primary analyses, and separately relative to the normative DMV sample mentioned above (Cox, 2014) to provide additional insights into the driving performance of both groups relative to experienced drivers (presented in Table 3).

Data Analysis

We used a multi-tier approach to examine the interrelation among driving performance and executive functioning in adolescents and young adults with and without ASD. In the first tier, demographics and basic motor skills were assessed, and significant between-group differences were tested as covariates for all additional analyses. In the second analytic tier, we assessed between-group differences in tactical driving performance using the empirically derived Tactical Driving Composite, with Bonferroni-corrected post hoc tests to examine the extent to which any observed differences were attributable to specific driving behaviors. The third tier examined performance on the executive functioning tasks (response inhibition, working memory), and the final tier used ANCOVA to examine the extent to which ASD tactical driving impairments may be attributable to motor and executive functioning differences detected in the preceding tiers.

Due to simulator recording error, one ASD participant's tactical driving data were missing (n = 43). Similarly, five individuals (4 ASD, 1 comparison) had non-usable

operational task data due to using two feet (i.e., braking with left foot while simultaneously pressing gas with right foot) (final $n = 39$).

Results

Tier I: Demographics and Basic Motor Skills

There were no significant differences in race/ethnicity between the ASD and comparison group participants (Table 1), and all participants were male. However, the ASD group ($M = 18.29$, SD = 2.29) was significantly older than the comparison group ($M = 16.59$, SD = 0.55; $p < .01$). With regard to basic response speed (Table 2), the ASD group was significantly slower than the comparison group during the steering (hand/arm) motor task ($p < .001$) but not the braking (foot/leg) motor task ($p = .14$). Similarly, the groups did not differ significantly in performance on the combined steering/braking dual processing task ($p = .25$). Age and arm/hand reaction time were not significant covariates of any of the analyses reported below (all $p \geq .37$). We therefore report simple model results with no covariates.

Tier II: Tactical Driving Performance

As shown in Table 3, the comparison group performed significantly better on the Tactical Driving Composite than the ASD group (p = .009, $d = 0.88$). Exploratory post-hoc analyses of the 14 variables that comprise the Tactical Driving Composite, corrected for multiple comparisons (critical $\alpha = .003$), revealed that these between-group differences were primarily attributable to "bumping" the lead car ($d = 1.09$), increased swerving (SD of lane position; $d = 0.26$), and increased lane changes ($d = 1.04$) (all $p < .003$).

Tier III: Executive Functioning

The 2 (group) x 2 (response inhibition, working memory) ANOVA for the percentage of correct steering and braking was non-significant for group (p = .861) and condition (p = .831), whereas the interaction effect was significant (p = .006) (Table 2; Figure 2). Post-hoc tests revealed that the significant interaction shown in Figure 2 was attributable to the differential effects of adding working memory demands for ASD relative to non-ASD adolescents and young adults. That is, between-group differences in steering/braking did not reach significance for either the response inhibition (p = .146) or working memory (p = .174) conditions. However, the increase in working memory demands was associated with a significant one-tailed decrease in steering/braking performance for the ASD group (p = .10, d = -0.45) relative to a significant increase in steering/braking performance for the comparison group (p = .016, d = 0.54).

Examination of recall performance during the working memory complex span condition was consistent with the steering/braking performance changes reported above, and revealed that the comparison group recalled significantly more signs in the correct serial order than the ASD group (p = .026, d = 0.81) (Figure 2; Table 2). Collectively, results of the executive functioning tests revealed that adding working memory demands to a complex driving task significantly disrupts driving performance for adolescents and young adults with ASD, as evidenced by significant increases in steering/braking errors and overall lower working memory performance.

Tier IV: Association Between Working Memory, Motor Speed, and Tactical Driving

In the preceding analyses, we found that adolescents and young adults with ASD have significantly slower hand/arm reaction time (steering) and decreased working

memory capacity relative to healthy controls. In the final set of analyses, we assessed the extent to which these difficulties were associated with their overall impaired tactical driving performance. To accomplish this goal, we repeated the Tier II analysis using ANCOVA to assess between-group differences in tactical driving performance with working memory (percent of signs recalled in the correct serial order) and hand/arm reaction time (seconds) as covariates. Results revealed that working memory (p = .009), but not hand/arm RT (p = .73) was a significant covariate of the Tactical Driving Composite; however, between-group differences in tactical driving performance remained significant (p = .048) after accounting for working memory. In other words, these results suggest that underdeveloped working memory abilities may help explain some of the tactical driving difficulties experienced by drivers with ASD, but additional variables will be needed to fully understand the mechanisms and processes underlying impaired driving performance among adolescents and young adults with ASD.

Discussion

The present study was the first to examine the impact of motor and executive functioning on tactical driving performance for adolescent and young adult drivers with autism spectrum disorder (ASD) relative to healthy controls. Drivers with (n = 17) and without (n = 27) ASD completed a series of tactical and operational tasks in a highly immersive simulator currently being tested by the Virginia DMV. Results revealed that drivers with ASD had significantly slower reaction times during steering (d = 1.45) but not braking. In addition, adolescents and young adults with ASD demonstrated impaired working memory functioning (d = 0.81), such that adding working memory demands resulted in a significant decrement in their driving performance relative to healthy control

drivers. Importantly, working memory abilities, but not motor speed, served as a significant covariate of driving ability, suggesting that working memory may reflect an important mechanism underlying some of these drivers' on-road difficulties. In contrast, drivers with ASD performed similarly on driving tests assessing their ability to flexibly shift between steering and braking, and drivers with ASD successfully inhibited responses at similarly high levels relative to healthy control adolescents.

Results from the tactical drive reveal that adolescents and young adults with ASD demonstrated poorer overall driving ability relative to novice drivers without ASD, despite being significantly older. This finding is consistent with previous investigations (Classen et al., 2013; Cox et al., 2012; Huang et al., 2012, Reimer et al., 2013), and extends this line of research by providing an initial examination of the role of executive dysfunction in these driving difficulties. Further, the current findings support the need for driving interventions and technological accommodations for this population given the association between tactical driving performance and on-road collisions (Cox, 2014). In the current study, the impaired driving performance of drivers with ASD appeared attributable primarily to steering and braking performance, rather than speed control or judgment variables. Specifically, adolescent and young adult drivers with ASD were more likely to "bump" the car in front of them, and less likely to maintain consistent lane positioning relative to novice, non-ASD drivers. Given this pattern, we might expect an association between driving performance and basic motor skills associated with steering and braking. Basic hand-eye (steering) and foot-eye (braking) reaction time, however, were not significant covariates of tactical driving performance, suggesting that alternative

mechanisms and processes are needed to explain driving difficulties for adolescents and young adults with ASD.

Deficits in executive functioning have been well-documented in the ASD literature (Hill, 2004; Liss et al., 2001; Ozonoff et al., 1991); this study's findings highlight the influential role these higher order abilities play in driving performance for this population. Interestingly, the ASD group did not demonstrate impaired performance during response inhibition or dual processing tasks, whereas the addition of a working memory task (road sign recall) differentially impacted drivers with ASD. Not only did the ASD group recall significantly fewer signs in the correct serial order than the comparison group, but they also demonstrated a differential decline in their driving performance with these added cognitive demands. These results are consistent with previous findings that adolescents and young adults with ASD have particular difficulty with multi-tasking while driving (Cox et al., 2012; Reimer et al., 2012), and extend the literature by suggesting that working memory abilities significantly predict simulated driving performance, which has been found to parallel on-road driving performance in earlier investigations (Cox & Cox, 1998; Cox et al., 1999).

Recognizing that adolescents and young adults with ASD performed similarly to their peers on most aspects of simulated driving (braking speed, flexibly shifting between steering and braking, correctly inhibiting braking and steering based on road demands), the current results suggest that driver training interventions should focus specifically on those areas where this population demonstrates deficits. In other words, driving training for adolescents and young adults with ASD may exert maximum benefits by focusing on training scenarios that require increased working memory demands (e.g., multitasking) –

particularly in the context of scenarios emphasizing consistent lane positioning and distance from a lead car, instead of more basic driving skills. Thus, we hypothesize that targeting working memory skills within a driving context (simulator) may improve driving-relevant working memory performance and expertise by increasing exposure to real-world scenarios that require this skill. Simulator-based interventions could also provide drivers with ASD a safe environment in which they would be exposed to multiple, relevant cognitive demands (e.g., sound system manipulation, GPS directions) while navigating a simulated course. Alternatively, assistive technology and adaptations could be developed to lessen the working memory demands required to operate a motor vehicle. More general working memory training programs may hold promise as well; however, we caution against using commercially available, computerized "working memory" training programs at this time given converging meta-analytic and experimental evidence that these programs fail to improve working memory (Rapport et al., 2013; Shipstead et al., 2012).

Regarding future directions, the healthy control group's improved performance on the steering/braking inhibition task in response to increasing working memory demands was contrary to performance patterns of experienced drivers in the normative sample (Cox, 2014) and aging drivers (Lambert, Cox, O'Connor, Cho, & Johnson, 2013; Watson et al., 2013), and suggests some modification to the simulator protocol. Specifically, typically developing adolescents and young adults may require more demanding tasks within this context (e.g., higher working memory set sizes). This hypothesis is consistent with developmental research demonstrating that executive functions such as working memory peak in early adulthood before showing age-related decline (Park, 2002), and

when considered in the context of the present findings allow us to speculate that better developed working memory may provide a partial buffer against these driver's on-road inexperience.

Limitations

The unique contribution of the current study was its investigation of the role of basic motor skills and executive functions in the driving difficulties experienced by adolescents and young adults with autism spectrum disorder (ASD). Several caveats require consideration when interpreting the present results despite these and other methodological refinements (e.g., use of mid-level driving simulator, assessment of executive functions in a driving-relevant context). Independent experimental replications with larger samples that include females, older drivers with ASD, and a more carefully matched comparison group are needed to confirm the present results. Notably, the comparison group was significantly younger but had recently obtained their license, whereas the ASD group had learner's permits. Although permit/license status and chronological age do not fully capture an individual's driving experience, the healthy control group likely had somewhat more driving experience, which may have contributed to the magnitude of observed group differences on the driving variables. In contrast, the increased age of the ASD group did not portend improved executive functioning as expected developmentally (Zelazo et al., 2004), and age was not a significant covariate in any of the analyses. Finally, working memory abilities predicted but did not fully account for between-group differences in driving performance, suggesting that future studies would benefit from examination of additional mechanisms and processes such as driver

anxiety, specific ASD symptoms, social relevance of road hazards, and visual field monitoring (Reimer et al., 2013; Sheppard et al., 2010).

Clinical and Research Implications

The current study was consistent with previous research documenting motor vehicle driving difficulties in individuals with ASD (Classen et al., 2013; Cox et al., 2012; Huang et al., 2012; Reimer et al. 2013), and extends this line of research by identifying specific areas of difficulty (maintaining consistent lane position and distance from a lead car) and implicating a specific executive function – working memory – in the driving difficulties experienced by these adolescents and young adults. In contrast, novice drivers with ASD did not demonstrate impairments in most basic driving skills, and were able to successfully flexibly shift between braking and steering, quickly brake in response to a lead car's brake lights, and quickly process on-road demands to successfully inhibit braking and steering when necessary in a simulated driving environment. Clinically, these findings suggest that driver training programs for adolescents and young adults with ASD may provide maximum benefit through repeated practice of scenarios that place relatively high demands on working memory (e.g., multitasking) while emphasizing consistent lane positioning and distance from a lead car – instead of more basic driving skills. In addition to increasing expertise, we hypothesize that simulated driver training may further improve driving performance for adolescents and young adults with ASD by decreasing anxiety (Reimer et al., 2013) through physiological habituation processes to the extent that each training session is of sufficient duration (i.e., 90 minutes or more). Thus, we propose that simulator-based driver training studies use extended training sessions and measure driving skill and physiological arousal, both within and across

sessions, to allow examination of the specific mechanisms and processes underlying training-related improvements for this population.

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Table 1. *Group Comparison of Demographic Characteristics*

	ASD (n=17)		**Comparison (n=27)**		**Analysis**		
	Mean	**SD**	**Mean**	**SD**	***t***	***p***	x^2
Age (years)	18.28	2.29	16.59	0.55	3.69	<.001***	
	n		**n**				
Gender(male)	17		27				44.00
Ethnicity (Caucasian)	17		23				2.77

*$p<.05$; **$p<.01$; ***$p<.001$

Table 2. *Group Comparison of Operational Driving Performance on Motor Response, Dual Processing, Response Inhibition, and Working Memory Tasks*

Operational Variable	ASD n=13		Comparison n=26				
	M	**SD**	***M***	**SD**	**F**	***p***	***d***
Composite							
Sample z-score	-0.24	0.51	0.09	0.32	5.40	.026*	0.41
DMV z-score	0.08	0.42	0.21	0.26	1.46	.235	0.93
Individual Variables							
Braking Reaction Time (sec.)	1.21	0.26	1.1	0.2	2.34	.142	0.51
Steering Reaction Time (sec.)	0.93	0.15	0.75	0.11	17.32	<.001***	1.29
DP: No. of Correct Responses	14.85	2.23	14.04	1.91	1.39	.246	-0.41
RI: No. of Correct Responses	15.62	0.65	15	1.41	2.21	.146	-0.52
WM: No. of Correct Responses	24.54	2.5	25.35	1.16	1.92	.174	0.71
WM: No. of Signs Recalled	14.62	4.66	17.04	1.89	5.38	.026*	0.81

Note: Operational composite was calculated using the average z-score of the six included individual variables. Sample z-scores were derived using scores from the study sample; DMV z-scores were calculated using scores obtained from a DMV normative sample. Reaction times are reported in seconds. No. of correct responses = Number of correct steering and braking responses according to task instructions. For dual processing, correct responses reflect braking to long and short brake lights and steering around filled and unfilled potholes. For the inhibition and working memory tasks, correct responses reflect braking to long brake lights, not braking to short brake lights, steering around unfilled potholes, and not steering around filled potholes. Also for working memory task, no. of signs recalled = the number correct signs recalled in the correct serial order (out of 18); ASD = autism spectrum disorder; DP = Dual processing task; RI = response inhibition task; WM = working memory task.
$^{*}p<.05$; $^{**}p<.01$; $^{***}p<.001$

Table 3. *Group Comparison of Tactical Driving Performance*

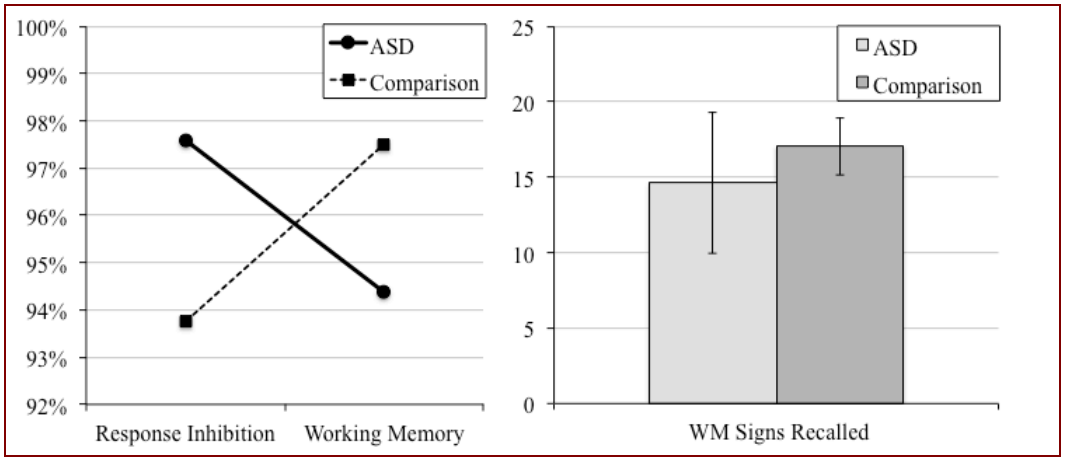
Tactical Variable	ASD n=16		Comparison n=27				
	M	**SD**	***M***	**SD**	**F(1,41)**	***p***	***d***
Composite							
Sample z-score	-0.22	0.57	0.13	0.29	7.46	.009***	0.88
DMV z-score	-1.88	2.27	-0.33	0.85	10.24	.003***	1.03
Individual Variables							
Acceleration, Tot MA	56.62	36.1	28.92	24.96	9.11	.004**	0.98
Bumps	2.06	2.49	0.37	0.63	11.43	.002***	1.09
Collisions	2.19	3.39	0.41	1.01	6.56	.014*	0.83
Deceleration, Tot MA	7.18	8.5	2.96	4.82	4.346	.043*	0.67
Lane Pos, SD Active	0.40	0.09	0.32	0.41	18.43	<.001***	0.26
Midline, Avg MA	1.85	1.58	1.24	1.61	1.47	.232	0.39
No Signal #LnChange	22.19	13.7	12.85	4.91	10.44	.002***	1.04
Off Road Resets	0.38	0.81	0.04	0.19	4.39	.042*	0.68
Off Road, SD TA	2.83	3.11	0.75	2.91	4.87	.033*	0.71
Rolling Stop Ratio	0.16	0.06	0	0	1.72	.197	4.51
Speed - 20 Avg TA	5.75	2.9	5.33	6.88	0.05	.819	0.07
Speed + 20, Tot TA	10.29	20.58	6.23	19.11	0.43	.516	0.21
Speed + 5, Tot TA	62.57	79.62	78.36	84.24	0.37	.548	-0.20
Tailgating	3.44	2.13	2.22	2.03	3.48	.069	0.60

Tactical composite scores were calculated using the average z-score of the 14 included individual variables. Sample z-scores were derived using scores from the study sample; DMV z-scores are calculated using scores obtained from a DMV normative sample. Avg = average; MA= magnitude active; TA= time active; Tot = total. Acceleration Total Magnitude Active = slamming on gas; Bumps = the number of collisions with another vehicle ≤ 5 mph; Collisions = the number of collisions with another vehicle > 5 mph; Deceleration, Total Magnitude Active = slamming on brakes; Lane Position, Standard Deviation Active = swerving; Midline, Average Magnitude Active = how far across and how long driver is in lane of oncoming traffic; No Signal, Number Lane Changes = the number of lane changes made without using turn signal; Off Road Resets = number of times driver failed to make a turn when instructed; Off Road Standard Deviation Time Active = variability of time driver was off road; Rolling Stop Ratio = the ratio of rolling stops (>0 and <5 mph) to complete (0 mph) stops; Speed -20 Average Time Active = average time spent 20 mph or more under posted speed limit; Speed +20 Total Time Active = total time spent driving 20 mph or more over the posted speed limit; Speed +5 Total Time Active = total time spent driving 5-19 mph over the posted speed limit; Tailgating = number of times driver is within 15 feet of lead vehicle.

**p<.05; **p<.01; ***p<.05/14 (.003; alpha adjusted for multiple comparison)*

Figure 1. *Driver Guidance System (DGS-78)*

Figure 2. *Group Comparison of Performance on Executive Functioning Tasks*



Note: Performance on response inhibition and working memory tasks were measured by percentage of braking and steering errors. Additionally, working memory was measured by number of signs recalled.

An Evaluation of Behavioral and Developmental Communication Interventions for Children with Autism Spectrum Disorder

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Introduction

Development and Diagnosis

Until recently, the three core criteria for Autism Spectrum Disorder (ASD) were communication deficits, impairment in social reciprocity, and the presence of restricted interests or repetitive behaviors (American Psychiatric Association; APA, 2000). The modifications put forth in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA, 2013) has merged the first two areas of deficits listed above, so that there are now *two* symptom clusters: social communication and restricted interests/repetitive behaviors. Although the DSM-5 has brought many changes to the classification of ASD, speech and language skills remain a primary focus when considering a diagnosis of ASD, stressing the importance of research and clinical programs focused on communication.

Since the above-mentioned symptoms fall on a continuum, the acquisition and developmental trajectory of early communication skills for individuals with ASD differs widely across the population (Charman et al., 2003; Fernell et al., 2010; Matson, Kozlowski, & Matson, 2012; Wetherby et al., 2004). Early language development is a cornerstone for the acquisition of basic communication and socialization skills; furthermore, a delay in expressive language is most frequently noted by parents as their first indication of atypical development (De Giacomo & Fombonne, 1998; Wetherby et al., 2004). Numerous studies to date have investigated early predictors of language development and outcomes among children with ASD (Charman et al., 2003; Mundy, Sigman, & Kasari, 1990; Stone & Yoder, 2001; Thurm, Lord, Lee, & Newschaffer, 2007). It has been demonstrated that imitation (Stone & Yoder, 2001; Thurm et al., 2007), play skills (McCune, 1995; Ungerer & Sigman,

1984), joint attention (Dawson et al., 2004; Mundy et al., 1990; Sigman et al., 1999), and cognitive ability (Lord & Schopler, 1989; Sigman et al., 1999) are predictive of future gains in communication skills.

Early Intervention

Research has also indicated that early communication skills can predict developmental trajectory and future outcomes (Dawson et al., 2004; Harris & Handleman, 2000; Stone & Yoder, 2001). Even though these early milestones inform later development, clinicians and researchers emphasize that early identification and intervention provide crucial contributions to more positive outcomes (Ben-Itzchak & Zachor, 2010; Landa, 2008; Wallace & Rogers, 2010).

Experimental research has demonstrated numerous positive effects of communication intervention for children with ASD including improved comprehension, production, and social use of language (Goldstein, 2002; Paul, 2008). Families and professionals are faced with a wide and assorted range of choices when selecting treatment approaches for individuals with ASD. Substantial evidence exists that there are efficacious interventions to promote language development in children with ASD (Goldstein, 2002; Koegel, 2000); however, researchers have emphasized the need for repeated empirical investigations into the numerous methods available (Boyd, Odom, Humphreys, & Sam, 2010; Howlin, Magiati, & Charman, 2009; Paul, 2008). As early diagnosis and intervention programs continue to be developed across the country, research has not yet identified the most effective method (or methods) of treatment for Autism Spectrum Disorder (Rogers & Vismara, 2008).

Intervention Methods

Behavioral Approaches. Behavioral approaches to intervention are based on the principles of learning theory and operant conditioning. At the core of this method is the principle that human behavior is learned and governed by antecedents and consequences. Therefore, as it applies to children with ASD, new skills can be acquired by presenting and/or modifying a given stimulus and providing reinforcement. During the implementation of these interventions, treatment goals are typically broken down into discrete steps, which are presented in a predetermined order that is guided by standard developmental sequences. Research has demonstrated that behavioral interventions have been implemented successfully to decrease negative behaviors as well as increase language, play, social, and academic behaviors (Schreibman, 2000). These programs are typically provided in clinical or home settings, one-on-one, and emphasize the importance of consistent, intensive levels of treatment for up to 40 hours per week (Reichow, 2012).

Investigations into behavioral approaches dominate the literature; although these studies exhibit methodological differences and varied outcomes, there is clear evidence of the efficacy of this approach. Published studies to date have demonstrated that behavioral interventions result in increased adaptive functioning, language proficiency, and IQ scores (Eikeseth, Smith, Jahr, & Eldevik, 2002; Lovaas, 1987; Smith, Groen, & Wynn, 2000). Limitations of this approach have also been identified (Schreibman, 2000). Critics attest that reliable comparisons have not been made between behavioral methods and alternative treatment methods. Additionally, due to the highly structured environment and dependence on prompts and reinforcers, it has been suggested that language and other behaviors taught by this method often do not generalize to other settings (Schreibman, 1997).

Developmental Approaches. Developmental approaches, which have also been referred to as relationship-based, focus on enhancing interactions and improving relationships between the child and parent (or other involved individuals) by facilitating positive exchanges and promoting reciprocity. Research has supported the relational foundation of Developmental interventions, demonstrating that increased synchrony and responsive interactions encouraged by this approach result in increased communication skills (Siller & Sigman, 2002). Developmental impairments associated with ASD affect a child's ability to connect with others, specifically caregivers, resulting in fewer positive, reciprocal interactions. Emphasizing that key emotional, social, and language skills are obtained through such interactions, this approach promotes these exchanges by following the child's lead.

Although developmental, relationship-based methods of intervention are commonly utilized in clinical practice and partially developed out of criticisms of intensive behavioral interventions, there are notably fewer published studies evaluating this approach. The studies available have shown increases in emotional, social, cognitive, and language functioning (Greenspan & Wieder, 1997; Rogers, Hall, Osaki, Reaven, & Herbinson, 2000; Solomon, Necheles, Ferch, & Bruckman, 2007). A commonly cited advantage of this approach is that it is easier for parents and other nonprofessionals to learn, and responses are more easily generalized to other contexts. In addition to noting the small number of research studies examining this approach, criticisms have also addressed the variation of administration due to a lack of set protocols and differences between individual therapists (Zachor, Ben Itzchack, Rabinovitch, & Lahat, 2007).

Design and Research of Intervention Programs

From October 2002 to May 2004, a working group sponsored by the National Institute of Mental Health (NIMH) convened to address methodological challenges in research on psychosocial interventions for Autism Spectrum Disorder (Lord et al., 2005; Smith et al., 2007). The group developed a model to systematically validate and disseminate interventions in a sequence of steps. The guidelines and recommendations were two-fold: 1) provide guidance to researchers on designing and conducting investigations on interventions for ASD; and 2) assist funding agencies in identifying current needs of the field and developing standardized criteria for assessing research proposals. As discussed above, previous research and literature reviews (Goldstein, 2002; Koegel, 2000) have documented efficacious intervention techniques to enhance language and communication skills for individuals with ASD; however, they are often missing the necessary components of monitoring the implementation and outcomes (Lord et al., 2005). Furthermore, the working group echoed the concerns of the American Psychological Association (APA) Task Force on Promotion and Dissemination of Psychological Procedures drawing attention to the *setting* where these interventions are evaluated (APA, 1995; Smith et al., 2007). Both groups called for adjusting the focus from *efficacy* of interventions in controlled treatment studies to *effectiveness*, emphasizing the importance of "real-world" investigations in community settings. To successfully apply and disseminate effective interventions the group identified four phases for researchers to follow: (a) formulation and systematic application of the intervention method, (b) development of a manual and a predefined plan for the evaluation of the intervention across sites, (c) running randomized clinical trials (RCTs), and (d)

conducting effectiveness studies on interventions in real world settings, conducted by community providers (Smith et al., 2007).

Rationale, Significance, and Purpose

Our previous investigation (see manuscript 1) compared outcomes of four language intervention approaches utilized by the UVA SPeech Language Intensive Summer Help (SPLISH) program during the summers of 2008, 2009, 2011, and 2012. These programs were directed by Dr. Jane Hilton, a doctoral-level speech-language pathologist with extensive experience with the ASD population. The first two summers consisted of combined interventions, with two administration orders (Behavioral-Developmental or Developmental-Behavioral). The following two summers consisted of two individual approaches (Behavioral Only or Developmental Only). Results of pre-post analyses revealed improvement across a broad range of nonverbal and verbal communication skills (as measured by the Communication and Symbolic Behavior Scales; CSBS, Wetherby & Prizant, 1999). Notably those who received the individual approaches yielded more gains than those who received the combined approaches across several subtests and overall communication composite scores of the CSBS (see Table 1 on page 47).

The summer language program conducted in 2013 built upon the previously established intervention design and procedure, expanding the battery of measures as well as the time points at which data were collected. The 9 children between ages 3 and 5 (*M =4.59,* SD = 0.91) who enrolled in this 6-week program were randomly assigned to receive either a *Behavioral* or *Developmental* approach; a combination of the approaches was not used due to previous findings noted above. In addition to the clinical and communication measures administered at pre-treatment and post-treatment sessions, additional measures were

collected at 2 and 4 months following the intervention. The battery of child measures and parent questionnaires collected at each time point was expanded to provide more information about communication as well as ASD symptomatology, cognitive abilities, adaptive skills, intervention history, and satisfaction with the program (Table 1).

Aims and Hypotheses. The primary aims of this study were to evaluate the feasibility of enrolling, retaining, and treating children with ASD, and tracking outcomes after treatment. Secondary aims were the preliminary examination of treatment outcomes and therapist acceptance of the protocol. Due to the size of the study sample (N=9), these assessments were primarily conducted on the combined group, and then the two approaches were qualitatively examined separately.

Regarding the intervention program's feasibility/accessibility, we hypothesized the six-week intensive language intervention would be acceptable and feasible for participants, their families, and therapists, with the following expectations: (a) All 9 participants would participate in the pre-treatment, post-treatment, 2-month follow-up, and 4-month follow-up visits (0% attrition); (b) To account for an expected small number of unreturned questionnaires, we anticipated participants would complete over 90% of program requirements (treatment sessions, parent questionnaires, and child clinical measures); (c) Parents and clinicians would find both treatment approaches acceptable (as measured by Client Satisfaction Questionnaire-8 and Summary Therapist Feedback Form); (d) Greater perceived barriers of participation identified by parents (as measured by the Barriers to Treatment Participation Scale) would be positively correlated with rates of missed sessions and percentage of incomplete parent questionnaires and child measures.

Regarding preliminary efficacy evaluations, we hypothesized verbal and nonverbal communication outcomes, as measured by the CSBS and parent-report language questionnaires (detailed below), would demonstrate greater gain by post-treatment, with maintenance and a more gradual increase in skills observed at the 2-month and 4-month follow-ups.

Method

Intervention Design and Procedures

Intervention Approaches. The summer programs utilized *Behavioral* and *Developmental* approaches to intervention. Both approaches were designed with goals established to focus on speech and language skills. These goals were broken down into separate steps and then sequentially taught to each child.

The *Behavioral* intervention involved a behavior modification approach for increasing desired behaviors in the child. The steps of this program included: 1) Child chooses reward; 2) Antecedent (stimulus) is presented; 3) Behavior is observed and child is prompted if necessary; 4) Behavior is reinforced with token; 5) Reward is provided after 10 tokens.

The *Developmental* intervention involved following the child's actions and expanding their communication to increase desired behaviors. Children who received this intervention approach had access to the same toys, materials, media, and activities as those who received the *Behavioral* approach; however, the children were allowed to direct the session by selecting which activity to begin. The steps of the *Developmental* intervention program included: 1) Observe child's behavior; 2) Open circle of communication; 3) Follow child's lead; 4) Expand or extend; 5) Close circle of communication.

Group Assignment. In order to control for internal validity threats from possible between-subject variation, participants were carefully screened and paired before pairs were randomly assigned to the intervention groups. Participants were manually matched as closely as possible on the following criteria: gender, chronological age, pre-treatment communication skills and functional language stage (CSBS, PPVT-4), ASD symptoms and severity (ADOS-2), adaptive skills (ABAS-II), and quantity of intervention previously received. The quantity of intervention received was reviewed by Dr. Hilton who qualitatively matched participants based on overall quantity and intensity of past intervention. Children were then were randomly assigned in pairs to the *Behavioral* and *Developmental* intervention groups to match the groups on these variables (see Table 2). Details of these measures are included below.

Treatment Sessions. Each intervention session consisted of three 50-minute blocks of intervention, with a 10-minute break between each block. Following the pre-treatment session (week 1), all participants received three-hour intervention sessions, four days per week for six consecutive weeks (weeks 2-7), followed by the post-treatment assessment session (week 8).

Clinician Training and Scheduling. In the month prior to the start of the intervention, graduate students from the UVA Speech and Language Pathology program were identified and underwent a two-week training, covering both methods of intervention. The selected clinicians had approximately equivalent experience with children diagnosed with ASD. A certified Speech and Language Pathologist, Dr. Hilton, who has experience in both *Behavioral* and *Developmental* intervention approaches, supervised all clinician trainings with the assistance of Clinical Instructors. Clinical Instructors possessed Masters'

degrees in Speech and Language Pathology and received a Certificate of Clinical Competence. All student clinicians received an introductory training packet that included relevant literature on each approach and the steps (outlined above) to be followed during the sessions. Dr. Hilton and the Clinical Instructors reviewed these steps in live training sessions and assessed each student clinician for adherence to the treatment protocols. During the training period, the clinicians' progress was monitored as they practiced each approach with other student clinicians as well as supervising faculty. Training was completed when all supervising faculty agreed that the clinician implemented the steps of each program correctly in these practice settings with 90% accuracy across three consecutive sessions.

One treatment block (50 minutes) of each intervention session was monitored by Dr. Hilton or a "floating" student clinician (not assigned to work with a child for the current block). These observers monitored clinicians' performance in one of two areas, on alternating weeks: (1) adherence to steps outlined above, and (2) data collection. Thus, one-third of every intervention session was reviewed to corroborate accurate data collection *or* proper implementation of the assigned intervention approach. Clinicians were then scheduled so that all participating children had equal time with each student clinician, and clinicians administered both methods of intervention equally over the six weeks of the program.

In order to track treatment outcomes, child clinical measures and/or parent questionnaires were completed at pre-specified intervals across the four time points: pre-treatment, post-treatment, 2-month follow-up, and 4-month follow-up. These included assessments of language, nonverbal communication, ASD symptomatology, adaptive behavior, and cognitive ability. See below for a description of the measures utilized; the schedule of measures is provided in Table 1.

Follow-Up. Two months following the post-treatment visit (October, 2013), participants were mailed a packet containing several parent questionnaires measuring communication skills. Four months following the post-treatment visit (December, 2013), a final visit was conducted at the Sheila Johnson Center, at which time additional parent-report measures were completed and clinical assessments administered to the participating children. In addition to providing clinical data, parents completed questionnaires assessing their satisfaction with the program and perceived barriers to treatment. Also at this time point, feedback on behavioral and developmental approaches was collected from clinicians to assess their acceptance of the protocols.

Participants

Nine children (8 male, 1 female) between 3 and 5 years of age (*M =4.59,* SD = 0.91) participated in the SPLISH program during the summer of 2013. Children with ASD were identified from the local community surrounding the University by local service providers (e.g., Speech and Language Pathologists and early intervention personnel), who were provided with materials to distribute to interested families. Additionally, eligible families who received speech therapy or assessment services at our clinic were given information about the summer program. Inclusion criteria included: a documented diagnosis of Autism Spectrum Disorder, between 2 (2:0) and 7 (7:0) years of age, English as a primary language, and no other comorbid disorder (e.g., Tourette's, Obsessive Compulsive Disorder). ASD diagnosis was confirmed by the administration of the ADOS-2 at pre-treatment session. Groups were matched on chronological age, pre-treatment language skills (as measured by the PPVT-4 and CSBS), and qualitative examination of the amount of intervention received. No significant group differences were observed at pre-treatment (see Table 2).

All children completed the 6-week treatment program (79%-100% sessions attended). Rates of post-treatment attrition were low All 9 participants completed the 2-month follow-up, whereas 1 of 9 stopped responding to correspondence prior to the 4-month follow-up visit; so, no 4-month follow-up data is available for this participant. The 8 remaining participants completed the program and all assessment visits. One of the nine participants utilized a voice-generating augmentative/alternative communication (AAC) device; therefore clinical measures of language and communication were not comparable to other participants. This participant was excluded from all analyses of clinical measures and parent questionnaires, including rates and percentages, since many of the forms were considered invalid. However, service satisfaction measures were collected from this child's parents and included in the feasibility and accessibility analyses presented below.

The University of Virginia Institutional Review Board approved the protocol, and parents of all participants signed corresponding informed consent form for treatment and participation in research program.

Measures

This study is focused on the development and successful implementation of the SPLISH intervention program. Given the size of the sample, and the preliminary nature of this investigation, several measures collected were used for descriptive purposes only at this time, to characterize our sample.

Measures: Characterization of Subjects

For this initial investigation, chronological age will be used as descriptive variable only. Additionally, the following measures were used as descriptive variables for our initial evaluation of the intervention program: (a) Comparison Score from the ADOS-2, (b)

Nonverbal Abilities, Verbal Abilities, and GCA scores from the DAS-II, and (c) Conceptual, Communication, and Practical Domain Scores, as well as overall General Adaptive Composite from the ABAS-II (Table 2).

Adaptive Behavior Assessment System – Second Edition (ABAS-II; Harrison & Oakland, 2003). The ABAS-II is a parent questionnaire that assesses adaptive skill functioning and provides 10 subscales that are used to calculate composites for Conceptual, Social, and Pragmatic domains as well as an overall score, the General Adaptive Composite (GAC). The ABAS-II demonstrates excellent internal consistency for all age groups, as measured by reliability coefficients, for the GAC (α =. 97-.99) and three domains (α = .91-.99). Internal consistency for these scores remains strong for clinical populations, including Autism, PDD-NOS, and Receptive/Expressive Language Disorder (GAC: α =.97-.98; domains: α = .92-.98) (Harrison & Oakland, 2003). The validity of this measure is supported by large magnitude correlations with the Vineland Adaptive Behavior Scales – Interview Edition (VABS-IE) on overall composite score (r = .70) and across the included three primary domains (r = .71-.77). Additionally, results of clinical validity studies indicate that the ABAS-II demonstrates good levels of sensitivity in differentiating between clinical and nonclinical samples (Harrison & Oakland, 2003). The ABAS-II was collected pre-treatment.

Autism Diagnostic Observation Schedule – Second Edition (ADOS-2; Lord et al., 2012). The ADOS-2 (Lord et al., 2012) is a 45-minute semi-structured play assessment with strong predictive validity relative to best estimate diagnoses (Gotham, Risi, Pickles, & Lord, 2007), and is considered by many to be the "gold standard" for classifying ASD. There are explicit standards for establishment of research reliability in its administration and scoring which, when upheld, results in relatively consistent scores and classifications. All

administrations of the ADOS-2 were scored by a clinical psychology doctoral student, who has extensive experience with the measure and is both research and clinically reliable on the measure. The ADOS-2 provides scores for Social Affect (SA; Communication and Reciprocal Social Interaction) and Restricted and Repetitive Behavior (RRB) as well as an overall score (sum of SA & RRB). Internal consistency of these subtests as measured by coefficient alpha were consistently high for the SA domain (.87–.92) and ranged from .51 to .66 in the Restricted, Repetitive domain. Test developers caution against using the raw scores as they are heavily influenced by age and verbal IQ (Gotham, Pickles, & Lord, 2009; Jones & Lord, 2012). To address these concerns, a Comparison Score is calculated, allowing for ASD severity to be quantified with relative independence from age and verbal skills. This score also allows for standardized, within- and between-child comparison of functioning over time and module for children of varying age and verbal ability. Gotham and colleagues (2009) reported that using these comparison scores in place of raw scores reduced the amount of variance in severity scores accounted for by Verbal IQ from 43% to 10%. This study administered the ADOS-2 pre-treatment to confirm participant diagnosis and as a measure of ASD severity.

Differential Ability Scales – Second Edition (DAS-II; Elliot, 2007a). The DAS-II is an objective cognitive instrument used to measure cognitive abilities in children as young as 2 years, 6 months. The DAS-II Early Years was administered to all participants at post-treatment to balance testing time for the pre-treatment and post-treatment visits. The Lower Level (ages 2:6 to 3:5) or Upper Level (ages 3:6 to 6:11) of the Early Years Battery was administered to all children based on their chronological age. An overall score, General Conceptual Ability Composite (GCA), as well as Verbal and Nonverbal Ability Cluster

scores, was obtained for all participants. The GCA is composed of four subtests for the Lower-Level Battery and six subtests for the Upper-Level. The Special Nonverbal Composite (SNC) and Spatial Ability Cluster are calculated only for the Upper-Level Battery and therefore will not be used in the descriptive characterization of this sample. The reliability and validity of this measure are well known, and include mean internal consistency reliability coefficients of .89-.95 for the above-mentioned scaled scores. Concurrent validity of the Early Years Battery is considered satisfactory, as evidenced by high correlations (r = .62-.81) with other measures of intelligence, academic achievement, mathematics, and reading and written language (*DAS-II;* Elliot, 2007b).

Intervention History Form. Parents completed an Intervention History Form (developed for this study) detailing their child's previous interventions including the method, duration, and intensity (i.e., number of hours per week). This form included services provided by private practitioners and/or through the child's school program. This form was collected pre-treatment, 2-month follow-up and 4-month follow-up; the primary purpose of this measure was to provide information regarding timing and amount of intervention (hours/week) participants received prior to, during, and following the intervention.

Measures: Feasibility & Acceptability

Given the feasibility and acceptability goals of this study, the following measures were used to measure satisfaction with the program as well as identify potential obstacles to completing the program.

Attendance and task engagement. To assess attendance and task engagement during the intervention, rates and percentages were calculated for the following variables: (a) missed sessions, (b) partial sessions (i.e., arrived late, left early), (c) missing or incomplete

questionnaires, and (d) attrition. Missing/incomplete questionnaires and attrition rates were calculated also at the 2-month and 4-month follow-ups to examine feasibility of following participants across multiple follow-up periods.

Barriers to Treatment Participation Scale (BTPS-Parent; Kazdin et al., 1997a; Kazdin et al., 1997b). The BTPS is a 44-item questionnaire assessing potential barriers to treatment completion. The BTPS utilizes a 5-point rating scale from 1 (never a problem) to 5 (very often a problem); in addition to an overall barriers score, there are four subscales: *Competing Activities/Life Stressors, Perceived Relevance of Treatment, Relationship with Therapist,* and *Treatment Issues/Logistics.* The BTPS also includes a separate scale reflecting the presence or absence of *Critical Events,* consisting of 14 dichotomous (yes/no) items. The parent version of this form was used in this study to identify barriers associated with treatment participation and correlate these perceived barriers with missing sessions, incomplete or missing questionnaires, any post-treatment attrition and need of engagement in additional intervention following treatment completion. Currently, there are no known studies within the ASD literature that have utilized this measure; therefore, details of its reliability and validity are provided here.

The BTPS has demonstrated good internal consistency as well as convergent and discriminant validity in an outpatient treatment setting (Kazdin et al., 1997b). Internal consistency, as measured by coefficient alpha, for the Parent and Therapist versions was .86 and .90, respectively. To measure discriminant validity, correlations were conducted to measure the extent to which perceived barriers can be explained by other parent and child characteristics known to be related to participation treatment (discriminant validity; e.g., parent stress, life events, adverse child-rearing practices, depression and other

psychopathology, and parent history of antisocial behavior). Although many of these were significant, they were in the low to moderate range (r= .15-.25), with a maximum shared variance of 6% with the Total Barriers Score (Kazdin et al., 1997a). Investigation of the subscales (Kazdin et al., 1997b) revealed high convergent validity as evidenced by significant positive relations between treatment participation (as measured by attendance rates) and all subscales, except *Treatment Demands.* The presence of critical events was not significantly related to participation in treatment ($p > .05$). Perceived barriers to treatment participation were examined using the parent version of the BTPS completed at 4-month follow-up (Table 3). In addition to an overall barriers score, the four subscales (*Competing Activities/Life Stressors, Perceived Relevance of Treatment, Relationship with Therapist,* and *Treatment Issues/Logistics*) were computed to examine targets for improving intervention completion and trial retention rates.

Client Satisfaction Questionnaire (CSQ-8; Attkisson & Greenfield, 2004; Larsen, Attkisson, Hargreaves, & Nguyen, 1979). The Client Satisfaction Questionnaire (CSQ-8) is an eight-item, self-report measure utilized to assess client satisfaction with mental health services across various dimensions: physical surroundings, procedures, method of treatment, clinicians, quality of service, length and quantity of treatment, outcome of treatment, and overall satisfaction. The CSQ-8 items are scored on a Likert-type scale ranging from 1 to 4 (total range: 8-32), with higher scores reflecting greater satisfaction. In the present study, total scores were used to measure parent satisfaction with the treatment program. Responses to individual items were assessed qualitatively to determine areas rated as needing improvement. Internal consistency reported for this measure has been high with alpha coefficients ranging from .84 to .93 (Attkisson & Greenfield, 2004; Larsen et al., 1979).

Factor analyses have repeatedly yielded one factor (Gaston & Sabourin, 1992; Nguyen, Attkisson, & Stegner, 1983). This measure was used to assess overall parent satisfaction with the program, and was collected at the 4-month follow-up (Table 4).

Summary Therapist Feedback Form (STFF; Crawley et al., 2013). The STFF is a 7-item therapist rating developed by Crawley and colleagues (2013) to measure the therapists' views on the appropriateness and ease of manual implementation as well as the session content and format. There are currently no reported validity or reliability estimates for this measure. Therapist-rated feasibility was assessed by examining therapist ratings (n = 12) on each of the seven STFF items for both the *Behavioral* and *Developmental* methods (24 forms total; Table 5).

Measures: Preliminary Efficacy Outcomes

Given the feasibility/acceptability goals of the current study, evaluation of treatment efficacy and impact on targeted communication skills represents a secondary, exploration aim. The goal of the interventions was to improve expressive language; therefore, well-validated measures of nonverbal and verbal communication were selected as the primary outcome variables.

Communication and Symbolic Behavior Scales (CSBS; Wetherby & Prizant, 1999). The CSBS is a widely accepted diagnostic protocol designed for children demonstrating a functional communication age between 8 months and 2 years (Wetherby & Prizant, 1999). It measures 22 factors related to communication that fall into seven communication clusters: communicative function, communication means-gestural, communication means-vocal, communication means-verbal, reciprocity, social-affective signaling, and symbolic behaviors. Standard scores from three CSBS subscales (Communicative Means-Verbal, Communicative

Means-Vocal, Communicative Means-Gestures) were selected *a priori* to assess expressive language across the pre-treatment, post-treatment, and 4-month follow-up assessments. The CSBS was conducted by trained examiners providing treatment for the children but blinded to study hypotheses. All CSBS testing sessions were videotaped and coded by independent examiners blind to study hypotheses and session (e.g., pre-treatment, post-treatment). During administration, the examiner allows the child to use communication skills in a natural environment by prompting and responding to communication initiated by the child. Scores are based on the types of interactions a child demonstrates during the administration (e.g., behavior regulation, joint attention, and sociability of communication function) as well as patterns of interaction with toys, caregivers, and examiners.

Internal consistency as measured by coefficient alpha for the Communication Composite (total score) is excellent (.91); coefficients for the included Clusters range from acceptable to excellent (.58 to .91), with one outlier, social-affective signaling (.17) (Wetherby & Prizant, 1999). Wetherby and Prizant (1999) report generally high inter-rater reliability with medians ranging from .83 to .90 across the 22 factors. Predictive validity was examined using a standardization sample and two groups of children with significant delays: Speech Language Impairments (SLI) and Pervasive Developmental Disorders (PDD). Correct classification was considerably higher than chance, 85% for PDD and 60% for SLI, and only 2 children (2.4%) of the standardization sample were misclassified using the CSBS. For this study, the rates of correct classification for PDD and misclassification are especially pertinent (Wetherby & Prizant, 1999).

MacArthur-Bates Communicative Developmental Inventories (MacArthur-Bates CDI; Fenson et al., 2007). The MacArthur-Bates CDI was completed by parents to gather

information about their child's communication skills. Both the *Words and Gestures* and *Words and Sentences* forms were completed on all participants to provide a comprehensive nonverbal and verbal communication inventory for all children. Test developers (Fenson et al., 1993; 2007) report a high degree of reliability for all major components of both inventory forms: *Words and Gestures* Total Gestures (.88), *Words and Gestures* Vocabulary (.95), *Words and Sentences* Vocabulary (.96), and *Words and Sentences* Complexity Scale (.95). For children over 12 months of age, test-retest reliability was stable across time for vocabulary production (> .90), vocabulary comprehension (>.80), and gestures (>.80) scores. The CDI has also demonstrated evidence for the predictive validity in the first 2 years, with 6 months between Time 1 and 2. Significant ($p < .01$) correlations were reported for vocabulary produced (.38), vocabulary comprehension (.44), and total gestures (.44). Stronger predictions were found across the third year of life for vocabulary produced (.58) and the complexity scale (.54; Fenson et al., 2007). We selected the Words Produced and Total Gestures subscales *a priori* to assess parental perception of their child's expressive language at pre-treatment, post-treatment, 2-month follow-up, and 4-month follow-up.

Peabody Picture Vocabulary Test – Fourth Edition (PPVT-4; Dunn & Dunn, 2007). The PPVT-4 is a widely used, norm-referenced assessment and was used to assess gains in receptive vocabulary from pre-treatment to 4-month follow-up. This measure has two forms, allowing for a second administration to be conducted within a short period of time. Alternate-form reliability for this measure is very high, falling between .87 and .93. The PPVT-4 demonstrates excellent reliability and validity; with internal consistency averaging .94 (Form A) and .95 (Form B) and moderate to high correlations with other measures of expressive and oral language. Total standard scores on the PPVT-4 expressive language test served as a

measure of receptive language. This measure was administered at pre-treatment (Form A) and 4-month follow-up (Form B) by trained examiners blind to group assignment (at 4-month follow-up, n/a at pre-treatment).

Rossetti Infant-Toddler Checklist (Rossetti, 1990). The Rossetti Infant Toddler Checklist is a criterion-referenced instrument that assesses Interaction-Attachment, Pragmatics, Gesture, Play, Language Comprehension, and Language Expression. This measure was used as parent report of verbal and nonverbal communication outcomes. Although over 120 research articles and publications have cited this instrument, the authors of this measure have not provided information on reliability or validity. The Rossetti was collected pre-treatment, post-treatment, 2-month follow-up, and 4-month follow-up.

Social Responsiveness Scale – Second Edition (SRS-2; Constantino & Gruber, 2012). The SRS-2 is a widely used screener and diagnostic tool used to identify individuals with Autism Spectrum Disorder in clinical and research settings. In addition to an overall score, the SRS-2 provides scores for five treatment subscales: Social Awareness, Social Cognition, Social Communication, Social Motivation, and Restricted Interests and Repetitive Behaviors. The total score and four of the treatment subscales (all except Social Communication) from the SRS-2 serve to measure changes in the other two core symptom areas of ASD: socialization and repetitive behaviors/restricted interests. Constantino and Gruber (2012) report multiple investigations of the SRS-2 have yielded an overall internal consistency, as measured by coefficient alpha, of greater than .95 for both clinical and nonclinical groups. Particularly of interest for this study, test-retest correlations (r) have averaged .90. Additionally, the measure demonstrates strong sensitivity (.78-.91), and specificity (.75-.90) with mixed diagnoses and typically developing contrast groups. The SRS-2 also correlates

well (.60-.77) with the time-intensive Autism Diagnostic Interview- Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003), considered to be the "gold-standard" autism interview protocol. This measure reflects the two domain factors used within the DSM-5: Social Communication and Interaction (SCI) and Restricted Interests and Repetitive Behavior (RRB). Factor analyses indicate both one (overall score) and two factor models (4 social subscales, 1 RRB) are appropriate to quantitatively map autism symptomatology (Frazier et al., 2014). Parents completed the SRS-2 at pre-treatment and 4-month follow-up. We selected the age-referenced Total Score and scores on the Restricted Interests and Repetitive Behaviors factor to provide an initial examination of potential generalized symptom changes outside of the targeted Communication domain.

Data Analysis

The primary aims of the study involved feasibility/acceptability assessment; therefore, these data were assessed via rates and percentages. Treatment acceptability was measured using rates of perceived benefit from treatment, whether respondents would recommend the program to others, and parent satisfaction with the program. Feasibility was assessed by rates of recruitment, attendance, retention, and attrition, as well as perceived barriers to treatment participation and feedback from the clinicians.

Preliminary efficacy evaluation reflects a secondary aim in the current pilot trial. Given power issues associated with the group and total sample sizes, we examined evidence of potential efficacy using the combined sample ($N = 9$); differential trends across the *Behavioral* and *Developmental* groups were examined qualitatively and displayed in Figures 1-5. All analyses were conducted using SPSS version 21.

Results

Acceptability

Responses from parents on the CSQ-8 indicated that they were generally pleased with the program (Table 4). Parents' ratings indicated they were satisfied with the quality of the intervention, found it helpful for their children, and noted their child's progress. All parents rated the quality of service they received as excellent (87.5%) or good (12.5%). Respondents indicated that most (50%) to almost all (50%) of their needs were met, and that they received the kind of service and quantity of help they wanted. Overall, parents reported that they were "mostly satisfied" (25%) to "very satisfied" (75%) with the intervention program, would be likely to recommend the program to a friend, and indicated they would return to the program if they were to seek services in the future.

Feasibility

Attendance and attrition. Overall, participation and retention were high. All nine participants were characterized as treatment completers – 100% completed the post-treatment and 2-month follow-up assessments. One family was lost to 4-month follow-up, resulting in an 89% completion rate at that time point. Attendance was also high across the 6-week intervention (91.7%). Six of the nine children (66.7%) missed two or fewer of the 24 intervention sessions, and no participants attended partial sessions (arriving late or leaving early). Total sessions attended ranged from 19 to 24 (M = 22, SD = 1.87). Parents completed 89.3% of clinical questionnaires and 88.9% of client satisfaction questionnaires across all four time points; 94.6% of the planned clinical measures were successfully administered to children.

Barriers to participation. The BTPS was used to identify barriers associated with treatment participation (Table 3). Eight of the nine participating families completed this form (89%), which was administered at the 4-month follow-up. Attempts to contact the one additional family were unsuccessful, and so drop-out reason is unknown. These families generally identified very few problems affecting their participation, and endorsed the lowest rating ("not a problem") for 77.3% of all items. Among the subscales, respondents rated the Perceived Relevance of Treatment (mean rating = 1.4; SD = 0.29) and Treatment Issues/Logistics (mean rating = 1.4; SD = 0.25) subscales as the biggest barriers to participation; ratings for these items ranged from "not a problem" (k = 1-8) to "sometimes a problem" (k = 0-4). Examination of individual item endorsements suggested that parents identified the amount of time needed to complete paperwork/questionnaires (mean rating = 1.86; range = 1-3) and the program's cost (mean rating = 2; range = 1-3) as the primary obstacles. Handout clarity was generally good, with ratings generally suggesting that they were "somewhat" or "a little" confusing (mean rating = 1.63; range = 1-3). Half of respondents rated the quantity of work associated with the intervention as "a little more" to "more" than expected (mean rating = 1.63; range = 1-3).

To better understand the association between perceived barriers and treatment engagement, we correlated BTPS subscale scores, parent CSQ-8 ratings, and child attendance rates (number of missed sessions). Higher CSQ-8 satisfaction ratings on the quality of help received were strongly associated with fewer missed sessions (r = .87, p = .005). Surprisingly, competing activities/life stressors (BTPS) were also negatively related to the number of missed sessions (r = -.86, p = .006). In other words, families with better attendance records reported higher program satisfaction but more life stressors than lower

attending families. Qualitative review of the Competing Activities/Life Stressors items suggests that parents whose child missed fewer sessions tended to endorse higher ratings for "During the course of treatment I experienced a lot of stress in my life" and "Treatment added another stressor to my life." Finally, Ratings on the Treatment Issues/Logistics subscale were inversely correlated with the number of completed questionnaires (r = .82, p = .025). Within this subscale, parents who rated the cost of the program as more problematic were less likely to miss sessions (r = .73, p = .040) and also less likely to complete all requested questionnaires.

Therapist-rated acceptability. All clinicians (k = 12) completed the STFF twice at 4-month follow-up, once with regard to the *Behavioral* program and once with regard to the *Developmental* program (24 forms total) (Table 5). These ratings were collected to inform the adjustment and refinement of training procedures for future intervention programs. As shown in Table 5, most masters-level student clinicians reported that the manuals for both approaches were generally easy to understand, and believed the manuals contained the important elements and were absent superfluous elements. In contrast, a majority (66.7%) indicated that the number of sessions was too few to accomplish all treatment goals, and several (33.3%) reported difficulty conducting the treatment as outlined in the manual.

Preliminary Efficacy

Treatment-related changes in the primary outcome variables are shown in Figures 1-5. All results should be considered preliminary given the small sample size and absence of a control group. Overall, the results revealed significant gains in language and gestures from pre-treatment to 4-month follow-up, with the largest magnitude improvements detected on

parent-reported clinical measures across pre-treatment, post-treatment, and 2-month follow-up.

CSBS. As shown in Figures 1-3, the interventions were associated with increases in verbalizations, vocalizations, and gestures from pre-treatment to 4-month follow-up. Participants made the largest gains in verbalizations from pre-treatment (M = 10.00, SD = 1.83) to post-treatment (M = 11.71, SD = 2.36; d = -0.88), with a more gradual increase from post-treatment to 4-month follow-up (M = 12.14, SD = 2.34). The opposite pattern was observed for communicative vocalizations, with smaller gains from pre-treatment (M = 8.57, SD = 3.21) to post-treatment (M = 8.71, SD = 2.93) and larger standard score increases between post-treatment and 4-month follow-up (M = 9.43, SD = 3.21). Participants demonstrated a steady increase in gesture use from pre-treatment (M = 5.43, SD = 2.37) to 4-month follow-up (M = 6.00, SD = 1.53), with the largest gains being observed between pre-treatment and post-treatment (M = 5.86, SD = 1.95).

MacArthur-Bates CDI. Parents reported statistically significant improvements in their child's expressive language and gesture use as measured by the MacArthur-Bates CDI (Figures 4 and 5). According parent report, the average number of words produced increased from 172 to 261 between pre-treatment and 4-month follow-up (p = .004), with the bulk of this increase occurring between post-treatment and 2-month follow-up. A similar pattern was observed for total gestures, which increased from 32 at pre-treatment to 41 at 4-month follow-up (p = .006) primarily due to large gains between post-treatment and 2-month follow-up.

PPVT-4. A non-significant trend toward improved receptive language was observed on the PPVT-4 between pre-treatment (standard score *M* = 79.33, SD = 16.93) and 4-month follow-up (*M* = 82.00, SD = 18.06), (d = 0.17).

SRS-2. Parents reported overall lower ASD symptomatology at 4-month follow-up (Total *T*-score *M* = 70.40, SD = 11.42) relative to pre-treatment (*M* = 76.40, SD = 11.93) (d = -0.57). However, there was a smaller magnitude change observed within the Restricted Interests and Repetitive Behavior factor (d = -0.47).

Preliminary Comparison of Intervention Approaches

Qualitative examination across the *Behavioral* (n=4) and *Developmental* (n=4; n=3 at 4-month follow-up) interventions suggest that both approaches had high rates of acceptability and feasibility and yielded positive treatment effects, but demonstrated some differences in trajectory of skill development. Overall, the *Developmental* group tended to miss more intervention sessions (*M* = 2.2, SD = 2.2) than the *Behavioral* group (*M* = 1.8, SD = 1.7). The *Developmental* group also had a lower rate of questionnaire completion (*M* = 88.9%, SD = 16.7%) than the *Behavioral* group (*M* = 98.0%, SD = 3.9%). It is important to note, the child who did not complete the study was in the *Developmental* group, and accounts for a majority of non-returned questionnaires and measures. There were no notable differences in satisfaction and perceived barriers to participation between groups, as measured by the CSQ-8 total score, BTPS total score, or BTPS subscales (Tables 3 and 4).

Clinician ratings on the STFF highlighted some differences in the manuals and training for the different approaches (Table 5). According to responses on the STFF, clinicians found the training materials for the *Behavioral* approach easier to understand (*M* = 5.17) than those for the *Developmental* approach (*M* = 4.75), with 4 of the 12 clinicians

rating the latter as "somewhat" easy to understand or lower. In line with the premise of the approaches, clinicians also indicated that the *Developmental* approach allowed for more flexibility than the *Behavioral* approach.

A preliminary examination of the child clinical and parent report measures of verbal and nonverbal communication also revealed some differences between the two approaches (Figures 1-5). In general, the *Behavioral* group demonstrated larger gains than the *Developmental* group on the CSBS subscales (Figures 1-3). The overall pattern of treatment effect was also notably different – with the *Behavioral* group showing larger gains from pre-treatment to post-treatment, and minimal change from post-treatment to the 4-month follow-up. In contrast, the *Developmental* group, who obtained higher scores at pre-treatment on both the Communicative Means-Verbal and Communicative Means-Vocal subscales, showed minimal gains from pre-treatment to post-treatment on the CSBS but had larger gains from post-treatment to the 4-month follow-up. The other primary child clinical measure of communication obtained was the PPVT-4. A preliminary comparison of standard scores on the PPVT for the *Developmental* group shows a mean gain of 9.67 standard score points from pre-treatment to 4-month follow-up, while the *Behavioral* group had a mean loss of 4.33 standard score points.

According to parent report on the MacArthur-Bates CDI, the *Developmental* group obtained higher scores on all subscales at pre-treatment and demonstrated larger gains overall (Figures 4 and 5). Both groups showed minimal gains from pre-treatment to post-treatment and more substantial gains from post-treatment to 2-follow-up, and then minimal changes from 2-month follow-up to 4-month follow-up on all the Words Produced and Total Gestures subscales.

Discussion

A 6-week, 24-session intervention program (SPLISH) targeting communication skills was evaluated. This initial investigation found the program to be feasible, acceptable, and beneficial for young children with ASD. The program consisted of two approaches, *Behavioral* and *Developmental*, with the ultimate goal of making a direct comparison of these popular approaches to speech and language intervention within a clinical setting. Dr. Jane Hilton, a doctoral-level speech-language pathologist with extensive experience with the ASD population, led the trainings of both approaches. Graduate students from the UVA Speech-Language Pathology program served as clinicians for this summer program. Their training and supervision included introductory materials for both approaches, live training sessions, evaluation of administration prior to the start of the program, and continued assessment to ensure adherence to the treatment protocols during the program.

This preliminary examination identified high rates of satisfaction and notable treatment gains as well as descriptive barriers and needed protocol revisions to inform future efforts to increase access and refine best practices to improve outcomes for children and families affected by ASD. The present findings indicate that this intensive communication intervention program was both acceptable and feasible to parents. Parents reported being satisfied with the program, with high rates of attendance and completion of the included questionnaires. The most commonly endorsed potential barriers to participation included the cost of the intervention as well as the amount and clarity of requested questionnaires. With continued documentation of the speech and language skills observed during and following future summer programs, it is hoped additional funding will be obtained to help reduce the cost to parents. As this was an initial assessment of the program, a large number of parent-

report measures were included to provide comprehensive information about the program. Results revealed which forms provided the most information needed to track progress. Most notably, the Rossetti Infant-Toddler Checklist was most commonly noted as confusing to parents (i.e., incomplete forms, questions directed to clinicians) and did not provide usable data to track communication skills. Therefore, future programs will reduce and refine the parent-report battery to minimize the amount of work for parents. Additionally, an in-person overview of all forms to be collected at pre-treatment may help reduce future confusion when completing questionnaires.

Feedback from clinicians was generally positive but highlighted the need for more in-depth training of each approach and modifications to the training materials to improve clarity and familiarity with the interventions. Clinician feedback also indicated that more sessions may be needed to accomplish all the treatment goals. Gathering this information at multiple time points may provide more detailed information to guide instructors during the training and intervention program. These areas will need to be adjusted and piloted prior to the initiation of a larger RCT.

The initial outcomes of the SPLISH program are promising. Given the small sample it is important to consider these as primarily descriptive and qualitative. Overall, significant gains were reported in word count and notable gains observed in gesture use and non-word vocalizations within the clinic setting and by parents. Both the MacArthur-Bates CDI and CSBS showed improvements in these areas but the trajectories differed across the targeted skill and between parent report and clinical measures. Verbalizations (words and word combinations) from the CSBS showed the strongest increase from pre-treatment to post-treatment, with minimal change from post-treatment to 4-month follow-up. In contrast,

Words Produced from the MacArthur-Bates CDI and gains on the CSBS were most notable from post-treatment to 2-month follow-up, with minimal changes reported from pre-treatment to post-treatment or 2-month to 4-month follow-up.

Because the CSBS centers around an interactive assessment with clinicians it is reasonable to assume children would demonstrate increased language skills in the same clinical setting immediately following 6 weeks of working with the same clinicians. This discrepancy requires further evaluation, but a possible explanation lies in the timing of the intervention and follow-up time points. Two months following the intervention is approximately when school programs would have started and parents may have then had more opportunity to observe their children in similar interactive environments with other children and professionals. Additionally, because a (wait list) control group was not utilized, we are unable to assess the possibility that these gains are not due to maturation or other factors (e.g., age, intervention history) unrelated to our intervention program. Further evaluation of scores obtained on the Communicative Means-Verbal subscale of the CSBS revealed that many participants reached the maximum score for their language stage by the four-month follow-up time point. Therefore, the scores reported may underestimate the gains made following the intervention program. Changes in overall ASD symptomatology as reported by the SRS-2 total score and RRB subscale score demonstrate that communication is the area most notably improved from pre-treatment to 4-month follow-up. These findings support the intervention's benefit to targeted language skills and suggest that improvements in language exceed those in other areas, such as repetitive behaviors and social interaction.

Preliminary comparisons of the groups suggest that the *Behavioral* approach was related to greater gains on the CSBS while parent-report measures indicated a trend toward

greater gains by children in the *Developmental* approach. Additionally, the trajectory of skill development varied by approach, most notably on the CSBS where there was a trend toward the *Behavioral g*roup showing more gains pre-treatment to post-treatment, whereas the *Developmental* group demonstrated minimal improvement pre-treatment to post-treatment but more from post-treatment to 4-month-follow-up than the *Behavioral* group. Based on parent-report on the MacArthur-Bates CDI, the pattern of word and gesture use across the four time points was very similar for both groups; however, the *Developmental* group showed a steeper increase over time, resulting in larger gains overall.

There are several considerations to be made when reviewing these preliminary findings. As indicated above, many children reached the maximum score on the Communicative Means-Verbal subscale of the CSBS. At the 4-month follow-up all three children in the *Developmental* group achieved the maximum score, as well as two of the four children in the *Behavioral* group. Given this information, additional measures of expressive language will need to be incorporated into the pre-treatment, post-treatment, and 4-month follow-up visits to ensure these gains will be accurately measured. Although there were no significant differences in age or pre-treatment scores on communication measures, these may also play a role in the different trajectories observed and need to be further evaluated. It is also important to note that parents were not blinded to treatment approach and were invited to observe sessions; therefore some differences between parent report and measures conducted within the clinic could reflect expectancy effect and/or changes in parent-child interactions fostered by these observations. Additionally, although information was collected on the interventions pursued prior to, during, and following the intervention we have not yet

established a way to uniformly quantify this information to determine how these other programs may have influenced observed gains.

Overall these results indicate substantial gains in expressive language and gesture use during and immediately following the intervention program for both *Behavioral* and *Developmental* approaches. This preliminary investigation of the program finds it to be well accepted by participants with noted benefits, supporting continuation of the program. Future evaluations, augmented training procedures, and a modified battery of measures will help to better define and understand these developmental trajectories as well as establish refined protocols for future, larger efficacy studies.

Limitations

This study serves as a preliminary investigation to inform future ASD intervention programs at the University of Virginia and elsewhere. As emphasized throughout this manuscript, the primary aims were to evaluate the feasibility and acceptability of implementing and evaluating a communication intervention for children with ASD to inform the need for larger scale efficacy evaluations and direct comparisons between *Behavioral* and *Developmental* based approaches.

A primary limitation of this study is the small sample size, particularly for group comparisons. Additionally, six of the nine participants had enrolled in previous SPLISH programs. Although this speaks to parent satisfaction and the program is tailored according to the child's current language level, it is possible this may have influenced treatment effects. Regarding parent satisfaction and barriers to participation, because the one participant who did not complete the study also did not complete service satisfaction forms we were unable to ascertain the factors that influenced the family's decision to cease involvement in the

program. Some limitations were also identified due to the battery of measures administered. As discussed above, the primary measure used to evaluate communication skills during visits to the clinic, the CSBS, proved not to be appropriate to capture the higher level of verbalizations demonstrated by many of the participants at later visits. Lastly, it is important to consider the reliability of parent report; there were a few intervals at which parents reported small decreases in skills (number of gestures and/or words) from the previous time point. Although losses are possible within this population, these discrepancies highlight the potential for errors in parent-report measures.

Limitations regarding clinicians and their training are also important to consider. Because the SPLISH program is conducted within a University clinic that focuses on student training, these clinicians do not have the level of in-depth training and/or experience with these intervention methods that would be ideal for a direct comparison study and likely increase overall treatment outcomes of the intervention program. Additionally, in order to control for differences between clinicians, they were rotated each session so all student clinicians worked with all participants and therefore trained on both approaches. This may have inadvertently led to crossover in the administration of the two approaches. Although adherence to the program was recorded, because this is a small, unfunded pilot trial the level of treatment fidelity was limited as we were not able to utilize blinded observers.

Despite these limitations, feedback from satisfaction questionnaires as well as interviews with parents confirmed their confidence in the effectiveness of the program. The augmented battery and extended collection period also provided valuable insight for the revision of future programs, laying the groundwork for larger, standardized, empirical comparative investigations of intervention approaches.

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Table 1. *Child Clinical and Parent-Report Measures Schedule*

	Pre-Treatment	Post-Treatment	+2 Month (Mailing)	+4 Month Visit
Child Clinical Measures				
ADOS-2	x			
CSBS	x	x		x
DAS-II		x		
PPVT-4	x			x
Parent-Report Clinical Questionnaires				
ABAS-II	x			
Intervention History Form	x		x	x
MacArthur Bates CDI	x	x	x	x
Rossetti Infant Toddler Checklist	x	x	x	x
SRS-2	x			x
Accessibility & Feasibility				
BTPS				x
CSQ-8				x
Clinician Feedback				
STFF				x

Table 2. *Group Comparison of Age, ABAS, ADOS-2, CSBS, DAS, and PPVT-4 Mean Scores at Pre-Treatment*

	All (n=8)		Behavioral (n=4)		Developmental (n=4)		Analysis		
	Mean	SD	Mean	SD	Mean	SD	*t*	*p*	x^2
Age (years)	4.59	0.91	4.83	0.80	4.35	1.08	0.72	0.50	
CSBS Language Stage	3.38	.916	3.25	.957	3.50	1.00		0.55	1.20
ABAS-II Communication	74.17	22.60	72.67	21.50	75.67	28.50	-0.15	0.89	
ABAS-II Conceptual	76.50	21.40	73.67	18.15	79.33	28.15	-0.29	0.78	
ABAS-II Practical	59.17	14.91	58.00	11.30	60.33	20.60	-0.17	0.87	
ABAS-II GAC	66.17	20.05	64.00	15.52	68.33	27.39	-0.24	0.82	
ADOS-2 CS	6.13	0.99	5.50	0.58	6.75	0.96	-2.24	0.07	
CSBS CM Gestural	5.62	2.26	5.50	3.11	5.75	1.50	-0.15	0.89	
CSBS CM Verbalizations	9.88	1.73	9.25	0.50	10.50	2.38	-1.03	0.34	
CSBS CM Vocalizations	8.75	3.01	7.25	3.86	10.25	0.50	-1.54	0.17	
DAS-II GCA	55.63	21.32	50.50	17.14	60.75	26.40	-0.65	0.54	
PPVT-4	78.29	15.70	81.33	13.20	76.00	18.99	0.41	0.70	

Note. CSBS Language Stage: 1 = prelinguistic; 2 = early one word; 3 =late one word; 4 = multiword

Table 3. *Mean Ratings and Range of Barriers to Participation Scale (BTPS) Subscales and Four Highest Rated Items*

	All (n=8)		Behavioral (n=4)		Developmental (n=4)	
	M(SD)	Range	M(SD)	Range	M(SD)	Range
Competing Activities/Life Stressors	1.20(.26)	1-4	1.21(.23)	1-3	1.88(.32)	1-4
Relevance of Treatment	1.36(.29)	1-3	1.38(.37)	1-3	1.35(.24)	1-3
Relationship with Therapist	1.10(.22)	1-2	1.21(.25)	1-2	1.00(.14)	1-2
Treatment Issues (Logistics)	1.35(.25)	1-3	1.38(.15)	1-3	1.33(.34)	1-3
9. *I felt the treatment cost too much.*	2.00(.54)	1-3	2.00(0.00)	2	2.00(.82)	1-3
12. *Information in the session and handouts seemed confusing.*	1.63(.92)	1-3	2.00(1.56)	1-3	1.25(.50)	1-2
22. *I felt this treatment was more work than expected.*	1.63(.74)	1-3	1.75(.96)	1-3	1.50(.58)	1-2
34. *I did not have enough time for the assigned work.*	1.86(.69)	1-3	2.00(.86)	1-3	1.67(.58)	1-2

Note. Likert scale responses by question were as follows: Question (9) 1 = Cost was fine, 2 = Cost was about right, 3 = Cost was sort of high, 5 = Cost was too high; Question (12): 1 = Not confusing at all, 2 = A little confusing, 3 = Somewhat confusing, 4 = Often confusing. 5 = Very often confusing; Question (22): 1 = Not more work than expected, 2 = A little more work than expected, 3 = More than expected, 4 = Quite a bit more than expected, 5 = Very much more work than expected; Question (34): 1 = Never a problem, 2 = Once in a while, 3 = Sometimes a problem, 4 = Often a problem, 5 = Very often a problem.

Table 4. *Parent Ratings on the Client Satisfaction Questionnaire (CSQ-8)*

	All (n=8)		Behavioral (n=4)		Developmental (n=4)	
	M(SD)	Range	M(SD)	Range	M(SD)	Range
1. How would you rate the quality of service you received?	3.88(.35)	3-4	3.75(.50)	3-4	4.00(0)	4-4
2. Did you get the kind of service you wanted?	3.38(.52)	3-4	3.25(.50)	3-4	3.50(.58)	3-4
3. To what extent has our program met your needs?	3.50(.54)	3-4	3.25(.50)	3-4	3.75(.50)	3-4
4. If a friend were in need of similar help, would you recommend our program to him or her?	3.50(.54)	3-4	3.25(.50)	3-4	3.75(.50)	3-4
5. How satisfied are you with the amount of help you have received?	3.63(.52)	3-4	3.50(.58)	3-4	3.75(.50)	3-4
6. Have the services you received helped you to deal more effectively with your [child's] problems?	3.50(.54)	3-4	3.25(.50)	3-4	3.75(.50)	3-4
7. In an overall, general sense, how satisfied are you with the service you have received?	3.75(.46)	3-4	3.75(.50)	3-4	3.75(.50)	3-4
8. If you were to seek help again, would you come back to our program?	3.75(.46)	3-4	3.75(.50)	3-4	3.75(.50)	3-4

Table 5. *Clinician Ratings on the Summary Therapist Feedback Form (STFF)*

	All	Behavioral	Developmental
How easy was it to understand the content of the manual?			
M(SD)	4.96(1.08)	5.17(1.03)	4.75(1.14)
How easy was it to conduct the treatment as outlined by the manual?			
M(SD)	4.54(1.44)	4.50(1.45)	4.58(1.51)
How user-friendly were the treatment materials (manual, workbook)?			
M(SD)	4.79(1.10)	4.83(1.03)	4.75(1.22)
Did the manual allow for enough flexibility?			
M(SD)	4.67(1.40)	4.08(1.38)	5.25(1.22)
Did you feel the number of sessions were sufficient to accomplish all of the treatment goals?			
M(SD)	4.71(1.37)	4.58(1.56)	4.83(1.19)
Were there any unnecessary elements included in the manual?			
M(SD)	5.25(1.11)	5.08(1.08)	5.42(1.17)
Were there any important elements missing from the manual?			
M(SD)	5.29(1.40)	5.42(1.56)	5.17(1.27)

Note. Items rated on a 1 to 7 Likert scale where 1="Not at all," 4="Somewhat," 7="Very Much."

Figure 1. *Standard Scores on CSBS Communicative Means-Gestural Subscale at Pre-Treatment, Post-Treatment, and 4-Month Follow-Up*

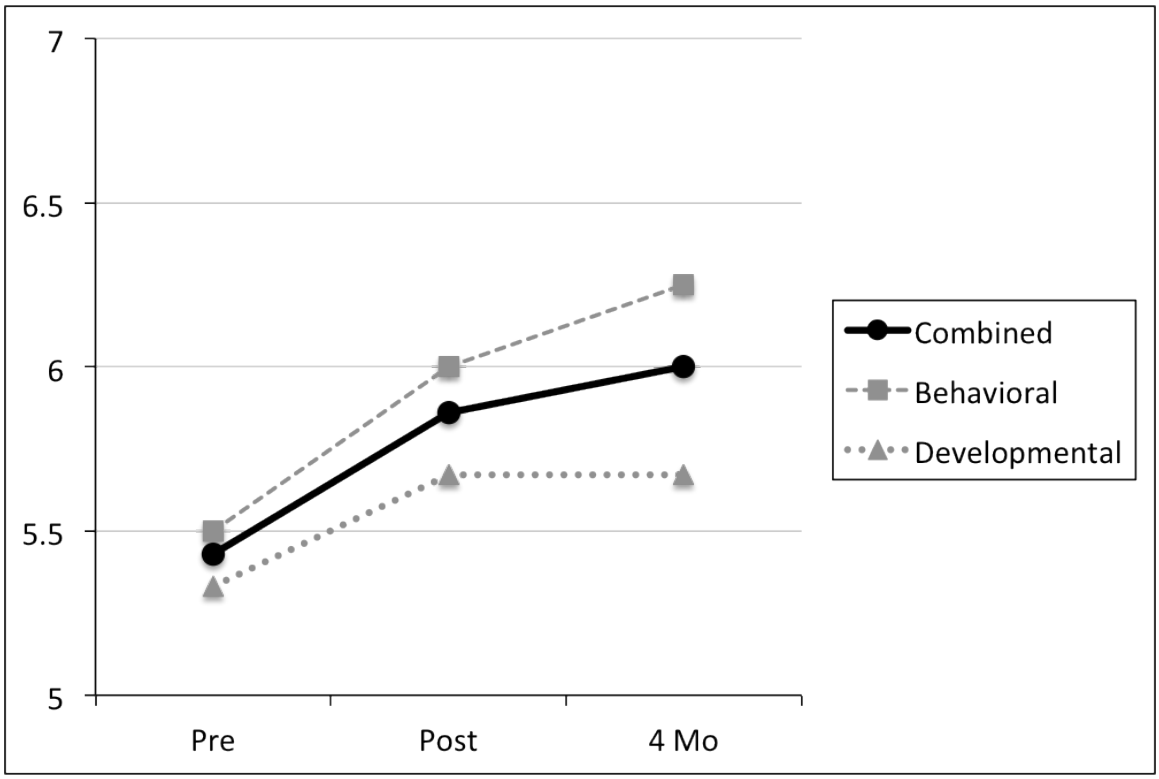

Figure 2. *Standard Scores on CSBS Communicative Means-Verbal Subscale at Pre-Treatment, Post-Treatment, and 4-Month Follow-Up*

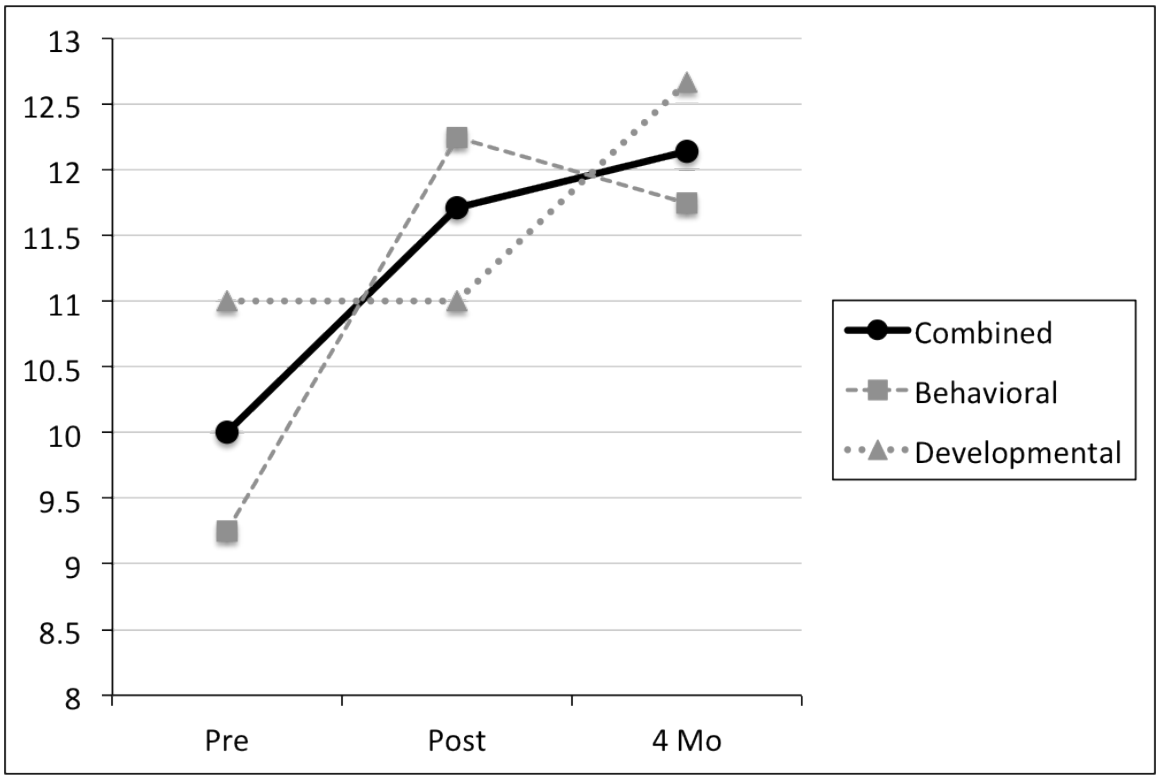

Figure 3. *Standard Scores on CSBS Communicative Means-Vocal Subscale at Pre-Treatment, Post-Treatment, and 4-Month Follow-Up*

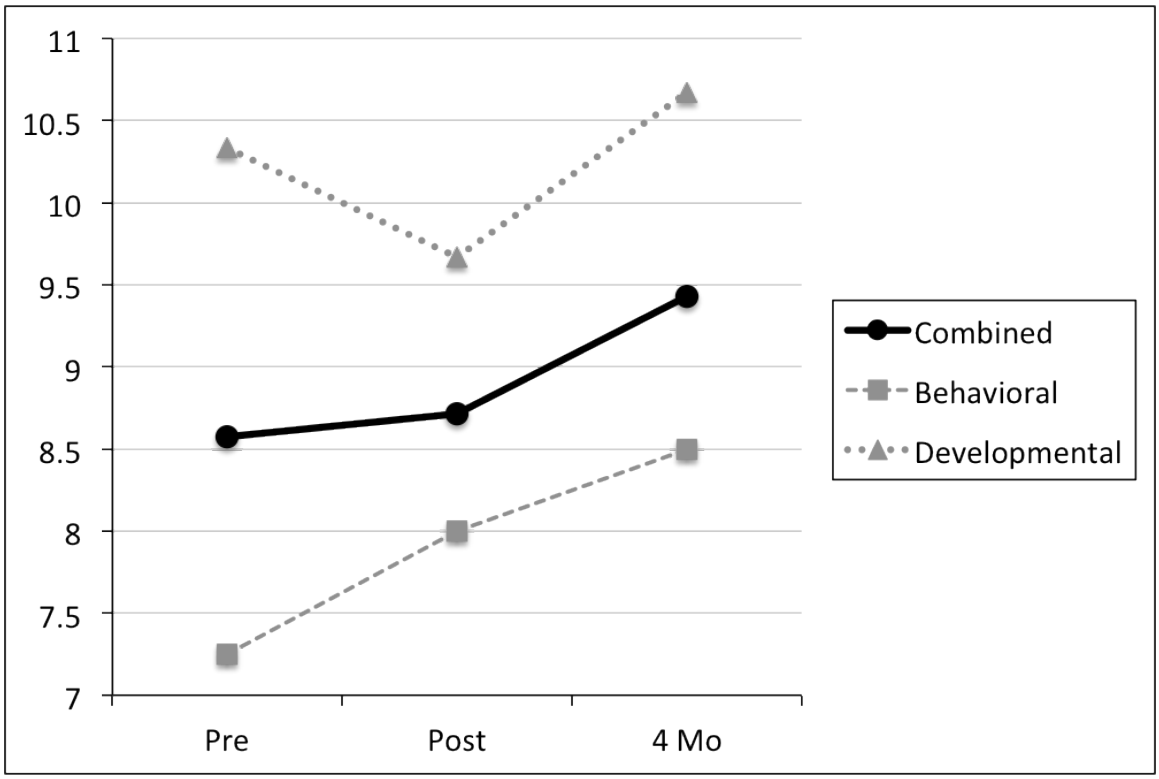

Figure 4. *MacArthur-Bates CDI Words Produced Reported at Pre-Treatment, Post-Treatment, 2-Month, and 4-Month Follow-Up*

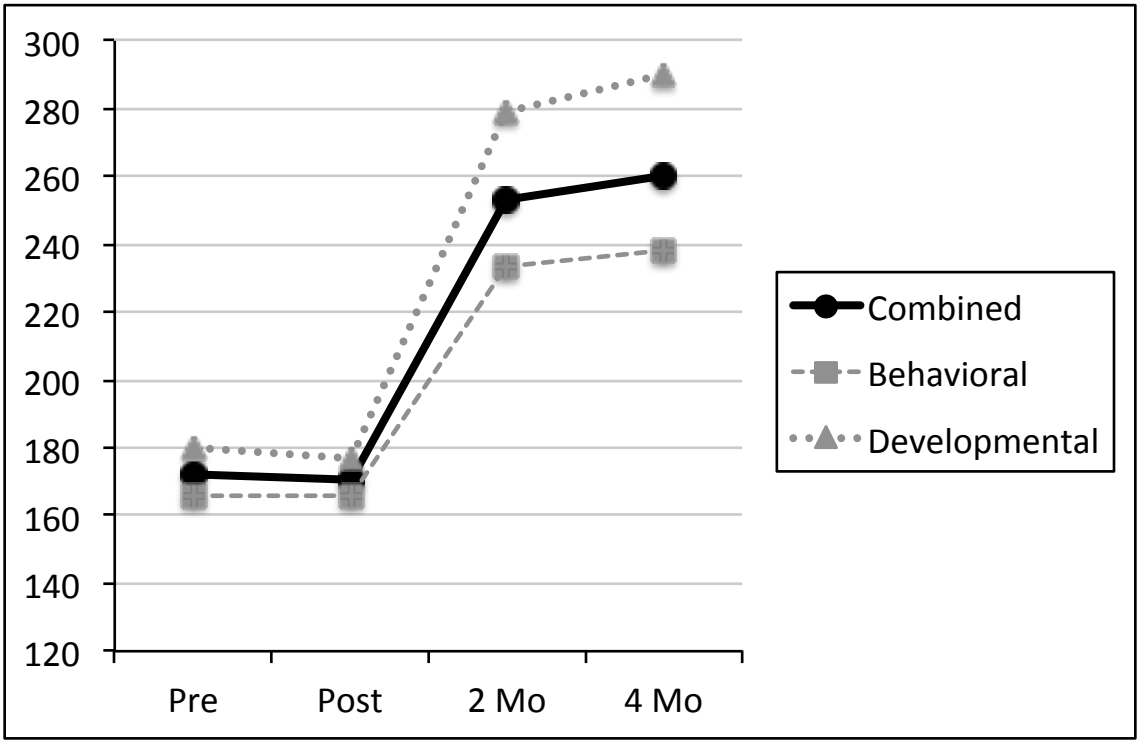

Figure 5. *MacArthur-Bates CDI Words Total Gestures Reported at Pre-Treatment, Post-Treatment, 2-Month, and 4-Month Follow-Up*