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Effects of DTT and NET on Adaptive Behavior in Toddlers with ASD

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Abstract:	Early intervention and Applied Behavior Analysis (ABA) have demonstrated beneficial outcomes for children diagnosed with Autism Spectrum Disorder (ASD) (Eikeseth et al., 2007; Peters-Scheffer et al., 2011; Vietze & Lax, 2018). The literature has yet to review the differential effects of Natural Environment Teaching (NET) and Discrete Trial Training (DTT) on adaptive skills. A sample of 142 children diagnosed with ASD between the ages of 16 and 35 months received either DTT, NET, or both interventions (NET+ DTT). The Bayley Scales of Infant and Toddler Development (BSID) Adaptive Subscale and the VB-MAPP Barriers Assessment were used as baseline and post-test measures. Children who received NET and NET+DTT conditions showed significant improvements compared to the DTT condition indicating that the addition of NET leads to increased adaptive skills and decreased barrier behaviors in participants. DTT may also play a necessary foundational role for children with more significant delays. These results provide support for the use of a combination of teaching strategies in community-based early intervention and refine protocols for teaching adaptive skills to toddlers with ASD.

EFFECT OF NET AND DTT ON ADAPTIVE BEHAVIOR

Abstract

Early intervention and Applied Behavior Analysis (ABA) have demonstrated beneficial outcomes for children diagnosed with Autism Spectrum Disorder (ASD) (Eikeseth et al., 2007; Peters-Scheffer et al., 2011; Vietze & Lax, 2018). The literature has yet to review the differential effects of Natural Environment Teaching (NET) and Discrete Trial Training (DTT) on adaptive skills. A sample of 142 children diagnosed with ASD between the ages of 16 and 35 months received either DTT, NET, or both interventions (NET+ DTT). The Bayley Scales of Infant and Toddler Development (BSID) Adaptive Subscale and the VB-MAPP Barriers Assessment were used as baseline and post-test measures. Children who received NET and NET+DTT conditions showed significant improvements compared to the DTT condition indicating that the addition of NET leads to increased adaptive skills and decreased barrier behaviors in participants. DTT may also play a necessary foundational role for children with more significant delays. These results provide support for the use of a combination of teaching strategies in community-based early intervention and refine protocols for teaching adaptive skills to toddlers with ASD.

Keywords: Autism Spectrum Disorder, Adaptive Behavior, Discrete Trial Training, Natural Environment Teaching, Early Intervention

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder marked by deficits in social communication, social interactions, and restricted repetitive patterns of behaviors or interests (American Psychiatric Association, 2013). About 33% of children diagnosed with ASD also have a comorbid intellectual disability (Maenner et al., 2020). Based on data collected through the Autism and Developmental Disabilities Monitoring Network on 8-year-olds throughout the United States, the CDC reports that, as of 2017, 1 in 54 children are diagnosed with Autism Spectrum Disorder (Maenner et al., 2020). Rising numbers in ASD diagnoses lead to concerns about resources and personnel to support these individuals, as young children, as school-age children, and as adults living and working independently.

ASD and Adaptive behavior

Adaptive behavior refers to a set of skills that allow an individual to function independently, particularly focusing on the domains of socialization, daily-living skills, and communication skills (Fenton et al., 2003; Pugliese et al., 2016). Adaptive skills are also defined as the "development and application of the abilities required for the attainment of personal independence and social sufficiency" (Sparrow et al., 1984). Adaptive skills, even in young children, support individuals to "meet the demands and expectations of their environment" (Tassé, 2021, p. 1). As one gets older adaptive skills become more complex to meet the challenges of more complex social and emotional responsibilities (Tassé, 2021).

The relationship between ASD and deficits in adaptive behavior has been repeatedly demonstrated, although the causation of these deficits remains debated (e.g., Gabriels et al., 2007; Kanne et al., 2010; Paul et al., 2014; Pugliese et al., 2016.) Cognitive abilities have been shown to be highly correlated with adaptive skills, suggesting that IQ is a strong predictor of adaptive skill level throughout the lifespan of an individual with ASD (Gabriels et al., 2007;

Kanne et al., 2010). Neidert et al. (2010) theorize that intellectual disabilities and developmental disabilities (IDD) pose many unique challenges to the normal acquisition of adaptive behavior because these skills are complex and cover a variety of domains. Behavior disorders are also commonly co-occurring in children with IDD that may impact adaptive skill instruction.

Conflicting research has demonstrated that ASD alone, without an intellectual disability or cognitive delay, will still lead to adaptive skill deficits (Paul et al., 2014; Pugliese et al., 2016). Language skills and communication skills may also play a critical role in adaptive skill development. When controlling for receptive and expressive communication skills at baseline, matched samples of children diagnosed with a developmental delay and ASD performed comparably on adaptive skill measures (Paul et al., 2014).

Adaptive Behavior Deficits in Early Childhood Population

Adaptive skills are, many times, conceptualized as skills that only apply to older adolescents and adults due to their focus on independent living. However, adaptive skill delays have been demonstrated in toddlers and young children under 3 years of age. Toddlers with ASD have shown delays in receptive communication, expressive communication, personal skills, interpersonal relationships, play/leisure skills, and socialization (Paul et al., 2014; Ray-Subramanian et al., 2011; Ventola et al., 2011). There is a need for research that specifically focuses on adaptive behavior as the primary dependent measure because adaptive skills delays may not improve over time and may continue to decline from early childhood into elementary age, without proper intervention (Farmer et al., 2018). Early intervention programs should be monitoring delays in adaptive skills in order to inform treatment plans and prepare children for long-term success.

Early Intervention

It is well established that using Applied Behavior Analysis (ABA) as an early intervention program is effective in treating language, social skills, and behavioral deficits in children with ASD (e.g., Foxx, 2008; Lovaas & Smith, 1988; Lovaas, 1987; Vietze & Lax, 2018). While more research focusing on adaptive behavior intervention is needed, research thus far has shown ABA as effective at treating adaptive skill deficits in children with ASD (Matson et al., 2012; Vietze & Lax, 2018). Beginning interventions at a young age with high dose levels leads to an increase in adaptive skills and a decrease of maladaptive behavior (Vietze & Lax, 2018). Even after only one year of ABA intervention, children can demonstrate an increase in adaptive behavior (Eikeseth et al., 2007; Peters-Scheffer et al., 2011). There is even some evidence that intensive early intervention has long term adaptive skills benefits into adulthood when ABA is delivered in high doses (Woodman et al., 2018).

Applied Behavior Analysis: Treatment Types

Normalized teaching interventions originated in the 1970s when Hart and Risley developed Incidental Teaching to increase language in at-risk children (Hart & Risley, 1968; Hart & Risley, 1974; Hart & Risley, 1975) after demonstrating that formal teaching sessions did not increase the rate of spontaneous language use (Hart & Risley, 1968). Teaching sessions, instead, took place during the child's free-play activities and were child-initiated (Hart & Risley, 1975). McGee et al. (1983) went on to apply this procedure to children with ASD and demonstrated an increase in receptive labeling that was generalized across contexts. Normalized teaching has evolved into a category of interventions called Naturalistic Developmental Behavioral Interventions (NDBIs) (Schreibman et al., 2015). NDBIs are influenced by findings in developmental psychology and take into account appropriate developmental skill and setting for intervention. Interventions take place in the child's natural setting and employ a child-led

structure, where the child initiates the teaching trials through their choice of materials, activities, and stimuli. The instructor may use environmental arrangements to prompt a teaching trial then use prompting and shaping to teach the target behavior (Schreibman et al., 2015). Teaching episodes rely on behavioral shaping, and reinforcement is functionally related to the stimulus. This loose structure allows for teaching to take place in the child's natural environment and vary between teaching episodes (Delprato, 2001). NDBIs include specific intervention curricula and techniques including Pivotal Response Training (Koegel et al., 1999), Incidental Teaching (McGee, 2005), Early Start Denver Model (Rogers & Dawson, 2020), Natural Environment Teaching (NET) (Sundberg & Partington, 1998), and Enhanced Milieu Teaching (Kaiser & Hester, 1994). The current study focuses on Natural Environment Teaching (NET) (Sundberg & Partington, 1998).

Lovaas (1987) introduced a method for using principles of Skinnerian operant conditioning to teach skills to children with ASD known as Discrete Trial Training (DTT). DTT teaches skills in a hierarchy, where mastery of one skill is required before moving on to the next. DTT tracks learning progress using short, repeated reinforcement trials and prompt fading techniques in a structured environment (Lerman et al., 2016). Since its origin, DTT has become one of the most popular and widely used methods of ABA therapy (Smith, 2001). The principles of Applied Behavior Analysis originate from B.F. Skinner's research on operant conditioning and schedules of reinforcement (Skinner, 1938; Skinner, 1958) and have since been applied to teaching children and adults with developmental disorders. Discrete trial training, now commonly called Discrete Trial Teaching (DTT), is the most commonly used method of ABA (Ghezzi, 2007).

Discrete Trial Teaching uses a teacher-led teaching method based on the three-term contingency of stimulus, targeted behavior or response, and reinforcer. The learner is presented with a simple discriminative stimulus, the learner supplies as response, and the response is reinforced if correct. Following the three-term contingency comes the intertrial interval to mark the end of one trial and the beginning of the next (Ghezzi, 2007; Leaf et al., 2016). DTT often also uses errorless teaching procedures therefore using a most to least invasive prompting procedure. DTT may use reinforcement functionally unrelated to the environmental setting or stimulus (Delprato, 2001). Teaching sessions are usually structured and repetitive taking place in an environment with little distraction (Leaf et al., 2016).

Limitations of the Current Literature

ABA treatment type may play a greater role in treatment effectiveness than current practice dictates. The efficacy of ABA treatment does vary (Jobin, 2020; Lax et al., 2023; Scherer & Schreibman, 2005; Schreibman et al., 2009; Schreibman et al., 2015; Schuetze et al., 2017). It is well established that behavioral interventions (ABA and behavior analytic-based interventions, like NDBIs) are more beneficial than eclectic interventions (e.g., Howard et al., 2014; Stanislaw et al., 2019). Research has moved beyond the outdated "behavioral treatment" vs. "eclectic treatment" dichotomy to elucidate specific benefits of individual ABA treatment types (Odom et al., 2012; Roane et al., 2016). The goal of comparing treatment types and modalities is to identify skill areas or developmental domains where a treatment modality is particularly beneficial. This information will aid clinicians in developing comprehensive and effective interventions that use a variety of treatment modalities to target specific skill areas.

It is reasonable to think that certain ABA treatment types may be more or less effective at targeting specific skills. DTT may be more beneficial when teaching skills that are not

intrinsically motivating to the learner or do not have clear functionally related reinforcers (Sundberg & Partington, 1999; Weiss, 2005). Academic skills such as number and letter recognition may be well suited to being taught through DTT procedures (Sundberg & Partington, 1999). NET may be more beneficial when targeting emerging language skills, group instruction skills, and social skills due to the embedded nature of learning. Skills are taught in their natural contexts and settings where the targeted behaviors can be modeled by peers (Cummings, 1999; Sundberg & Partington, 1999; Weiss, 2005). NET may also reduce some of the common problems that emerge with DTT such as a failure to generalize, increased avoidance behaviors, and prompt dependency and increase intrinsic motivation of the learner (Delprato, 2001; Haq & Aranki, 2019; Schreibman et al., 2015). Clinicians should capitalize on the strengths of different ABA approaches using a combination of approaches for holistic, comprehensive interventions (Weiss, 2005). These findings support current best practice that suggests a combination of both developmental and behavioral early intervention beginning as young as possible (Zwaigenbaum et al., 2015).

The current study has two goals. The first is to demonstrate that delays in adaptive behavior can be found in toddlers under the age of 3 years diagnosed with ASD/PDD-NOS. Second, to test for differential benefits of NET and DTT in increasing adaptive skills and decreasing maladaptive behavior, adding to the scope of previous NET/DTT research (Lax et al., 2023). Because of the unique strengths of DTT and NET, we hypothesize that participants who receive both NET and DTT treatment condition (NET+DTT) will demonstrate an increase in adaptive behavior and a decrease in maladaptive behavior compared with children who received NET or DTT treatment conditions alone. Adaptive Skills cover a relatively broad scope of

complex skills the NET and DTT combined condition may afford a more holistic treatment leading to the most beneficial outcomes in adaptive and maladaptive behavior.

Methods

Participants

The current sample and data were collected with the sample of participants reported in Lax et al. (2023). Furthermore the treatment protocol was the same as reported in Lax et al. (2023). This analysis was conducted to extend the impact of the treatment protocol examined in the previous study.

Participants consisted of 142 children (25% female) receiving early intervention at the Hand in Hand Early Childhood Center in New York City. Participants were referred to the program by the NYS Early Intervention Program due to signs of a developmental delay. Participants were between the ages of 16 and 35 months (M = 26.97, SD = 3.86) at intake and received a diagnosis of ASD or PDD-NOS[1] by a licensed psychologist based on clinical observation, parent report, and administration of the Childhood Autism Rating Scale-Second Edition (Schopler et al., 1986). Direct racial and ethnic data were not permitted to be obtained. Clinician observation indicated a representative sample of all racial groups and primary languages reported were typical of a large urban city (English (53.5%), Chinese (26.8 %), Spanish (18.3%), and other (1.4%)). The sample was also representative of the typical gender ratio for ASD diagnoses with 1 female receiving a diagnosis of ASD for every 4 males (Fombonne, 2009).

Assessments

[1] At the time of diagnosis, the DSM-V had not yet been adopted.

The assessments chosen for this study attempt to reflect the findings of Neidert et al. (2010) that adaptive skills deficits in ASD are caused by both limited social reinforcement and increased maladaptive behavior that inhibit instruction and typical adaptive skills development and attempt to measure both the strengths and weakness of the different ABA approaches.

Bayley Scale of Infant and Toddler Development, Third Edition: Adaptive Subscale

At intake, all participants were administered the Bayley Scales of Infant and Toddler Development, Third Edition (BSID), a standardized evaluation instrument (Bayley, 2006). The BSID was created to measure infant and toddler development from 1 month to 42 months of age and is appropriate to use to both identify areas of developmental delay and to track improvement over time (Albers & Grieve, 2007). The BSID shows excellent reliability and good predictive validity on the Vineland-II (Sparrow et al., 2005) standard scores and the WPPSI-III (Scattone et al., 2011; Wechsler, 2002). The assessment is delivered through direct probes, direct observation, and parent report.

The BSID is designed to assess five areas of development: cognitive, communication, physical, socio-emotional behavior, and adaptive behavior. The BSID Adaptive Behavior Subscale is administered through parent report and assesses skills such as communication, self-care, leisure, health, self-direction, and home living (Bayley, 2006). Standardized scores on the Adaptive Subscale are based on pass/fail criteria with a mean score of 100 and a standard deviation of 15. The Bayley Scales of Infant and Toddler Development, Fourth Edition, has since been released, but the current data were collected prior to its publication in 2019.

Verbal Behavior Milestones Assessment and Placement Program: Barriers Assessment

Participants were assessed at baseline using The Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP). The VB-MAPP is based on the principles of B.F.

Skinner's analysis of verbal behavior and is designed to assess verbal and related skills that are required to develop effective communication and social skills (Skinner, 1957; Sundberg, 2008; Sundberg, 2014). The VB-MAPP is a criterion-referenced instrument comprised of the Milestones Assessment, the Barriers Assessment, and the Transition Assessment. The main goal of the VB-MAPP is to assess baseline skill levels and areas of deficit in comparison to typically developing children scaled by age to inform treatment programming and monitor changes over time (Sundberg, 2008). Assessment data are collected through observation and direct probing of skills. The VB-MAPP has shown high to moderate reliability with the highest inter-rater reliability demonstrated for the Milestones Assessment (intraclass correlation = 0.876) and lowest inter-rater reliability for the Barriers Assessment (intraclass correlation = 0.629) (Montallana et al., 2019). The content validity for both the Milestones Assessment and Barriers Assessment is moderate to strong (Padilla & Akers, 2021). The VB-MAPP is the most commonly used assessment among ABA practitioners with 76% reporting using the VB-MAPP alone or in conjunction with other assessments (Padilla, 2020).

The Barriers Assessment measures 24 learning and language acquisition barriers common to children with ASD or a developmental delay that inhibit learning or teaching. The behaviors assessed include behavior problems, reinforcer dependence, self-stimulation, obsessive-compulsive behavior, sensory defensiveness, failure to generalize, weak motivators, etc. The Barriers Assessment is a criteria-referenced assessment and yields a sum score between 0 and 96. The lower the score the fewer barriers to learning and instruction exhibited by the child. The Barriers Assessment is meant to complement the Milestones Assessment by identifying specific barriers impeding the development of skills addressed on the Milestones Assessment (Sundberg, 2008).

Procedures

Participants were referred to the New York State Early Intervention Program due to suspected ASD or developmental delay and referred then for a developmental evaluation. With parent consent, children determined to have a developmental delay were referred to Hand in Hand Early Childhood Center to receive ABA therapy or other appropriate treatments.

At intake, a licensed psychologist delivered the CARS-2 to determine ASD diagnosis and the Bayley Scales of Infant and Toddler Development (BSID). The Adaptive subscale of the BSID was informed by observations and parent interview. The VB-MAPP was administered by a BCBA or RBT clinician experienced in delivering the assessment. The VB-MAPP Barriers Assessment subscale was administered through observational data collection. All assessors were blind to treatment condition. Both the BSID and VB-MAPP were again administered upon the child's exit from the program due to aging out around 3 years of age or as a result of qualifying for preschool early intervention.

Staff Training

All instructional classrooms are overseen by a Board Certified Behavior Analyst (BCBA) and use a 1:1 teaching model pairing one teaching assistant with each student. Teaching assistants undergo an Intensive Behavioral Skills Training program consisting of seven hierarchical phases lasting six weeks. The training program begins with a conceptual phase before moving to the classroom instruction phase. A teaching assistant must master all seven phases before being allowed to independently provide 1:1 ABA instruction. Mastery of phases was assessed using a series of checklists. Teaching assistants who did not achieve mastery were required to attend supplementary training and trained to criterion. Less than 20% of teaching assistants did not achieve mastery during fidelity checks. All 1:1 instructors received the same

training regardless of eventual classroom placement. Each classroom consists of no more than 10 children and is overseen by the BCBA at all times. BCBAs also directly supervise each teaching assistant weekly to ensure treatment fidelity. Additionally, every three months teaching assistants were reassessed using a mastery checklist.

Treatment Program

The assigned classroom BCBA is responsible for developing treatment goals for each child using the VB-MAPP Milestones Assessment and Barriers Assessment to develop treatment goals and track progress. The child's individualized treatment plan is based on VB-MAPP scores at intake regardless of classroom. The VB-MAPP objectives are used to identify larger goals based on the child's emerging skills while the classroom BCBA is responsible for creating the task analysis of the hierarchy of foundational target skills needed to meet the goal. Trial by trial daily data is taken for each target skill and percent accuracy calculated and graphed daily by the ABA therapist. Daily data informed ongoing changes to the treatment plan and was inspected weekly by the classroom BCBA to update treatment programs. BCBAs probed VB-MAPP goals weekly.

DTT Classroom.

Features of the NET and DTT classroom programs are highlighted in Table 1.

The DTT classroom instruction took place in a 1:1 treatment setting using therapist chosen activities and stimuli. Therapy sessions took place at tables with the therapist and child facing each other. Instructors were trained to use most to least prompting techniques and errorless teaching procedures. A five-trial teaching format was used to calculate progress. The child was presented with five massed trials for a target skill during the session. The percent of

successful trials out of total trials was calculated daily. Mastery was considered 80% accuracy across three sessions.

NET Classroom.

As previous discussed, there are many naturalistic environment approaches to intervention. The current study implements a curriculum based on the Natural Environment Teaching (NET) approach of Sundberg and Partington (1998) *Teaching Language to Children with Autism or Other Developmental Disabilities.* This curriculum is heavily influenced by Skinner's Analysis of Verbal Behavior (1957) and the Natural Language Teaching Paradigm (NLP) (Koegel et al., 1987). This particular NET approach was chosen because of the intervention center's use of assessment guided individual programming. The VB-MAPP seamlessly integrates with this NET curriculum as it is an expansion of the Assessment of Basic Language and Learning Skills (ABLLS) introduced by Sundberg and Partington (1998).

The curriculum begins with examining establishing operations in the child's natural environment to increase intrinsic motivation and begin pairing the instructor with reinforcers. Weiss (2001) emphasizes that NET focuses first on mand training through a series of prompting hierarchies, shaping, and reinforcement relevant to the discriminative stimulus (Shafer, 1999; Sundberg & Partington, 1999). Like other NDBIs, NET builds the context of teaching on the child's interest and child-led activities (Weiss, 2005). NET takes place in the developmentally appropriate setting for the child, often a play setting appropriate for young children (Shafer, 1999).

The NET classroom relies on group instruction and child-led activities with instruction taking place in a classroom that looks similar to a typical preschool setting. The sessions were initiated with a group carpet activity followed by the child choosing an activity center. The NET

children were paired 1:1 with an ABA therapist to follow the child's lead and facilitate environmental arrangements embedding instruction into the routine. The NET classroom instructors also used least to most prompting techniques. Children were presented with five teaching trials for each target skill throughout the session. This trial format was used to calculate progress. The percent of successful trials out of total trials was calculated daily. Mastery was considered 80% accuracy across three sessions.

Classroom Placement

Once the child was found to be eligible for early intervention, he or she was placed in an appropriate class representing one of two treatment types, DTT or NET. Criteria for inclusion in the NET classroom were based on the child's ability to attend to group activities due to the topography of NET group instruction. Eligibility criteria were measured by the VB-MAPP Classroom Routines and Group Skills Subscale with an inclusion score of 1. Those children who met criterion for group instruction skills at intake were placed in the NET classroom for more advanced instruction. Children who were initially placed in the DTT classroom were moved to the NET classroom as they met criterion in line with the center's model to place the child in his or her least restrictive environment. Progress on the VB-MAPP was tracked biweekly allowing for prompt transition to the NET classroom when the inclusion criteria were met.

For purposes of this study, three experimental groups were identified: NET group (n = 41), the children who received first DTT and then NET (NET+DTT) (n = 38), and DTT group (n = 57). Data were collected from a community sample where random assignment was not possible. Instructional sessions consisted of 2 hours of therapy with 5 sessions a week for the year from September to August. Participants in the NET + DTT group received and average of

98.6 session in DTT before moving to NET for an average of 162 sessions. All Participants received an average of 260 sessions in their respective experimental treatment group.

Results

Baseline Adaptive Skills

To test the hypothesis that children under 36 months of age diagnosed with ASD show delays in adaptive behavior skill acquisition, the frequency distribution of baseline scores of the BSID Adaptive Subscale was examined. These data are displayed in Table 2. Toddlers aged 16 to 35 months old showed delays in adaptive behavior (M = 62.01, SD = 10.66) with a mean score of 62.01, 3.5 standard deviations below the normative mean as measured by the BSID Adaptive Subscale as well as being 1.5 standard deviations below the average range of 85-115.

Furthermore, although there are no norms for the VB-MAPP, very high maladaptive behavior and barriers scores were also demonstrated by the VB-MAPP Barriers Assessment with a group mean score of 51.853, although a broad range in scores was observed (SD = 18.25) (Table 2).

Post-Test Adaptive Behavior and Barrier Behaviors

Random assignment of participants was not possible. ABA treatment is one of the accepted effective treatments available, therefore even a static control group would be unethical and interfere with the child's developmental progress (French & Kennedy, 2018; Green & Garg, 2018; Vietze & Lax, 2018). Thus, researchers conducted one way between groups ANOVAs on baseline scores to test for pre-test differences. The analysis for baseline adaptive behavior and barrier behaviors showed that the pre-test scores for both dependent variables were statically different ($F(2, 131) = 20.607$, $p < .001$; $F(2, 138) = 45.09$ $p < .001$, respectively). The analysis

for number of treatment sessions revealed no statistically significant difference among the three treatment groups ($F (2, 139) = 108$, $p = .898$). In addition, there was no significant difference for age at intake between the three treatment groups ($F (2, 68) = .156$, $p = .856$).

Language skills and cognitive development have been shown to be highly correlated with adaptive skills (Gabriels et al., 2007; Kanne et al., 2010; Paul et al., 2014; Pugliese et al., 2016; Ray-Subramanian et al., 2011; Ventola et al., 2011). To confirm that relationship in the current sample, a correlational analysis was conducted between baseline language and cognitive scores and adaptive behavior scores. This analysis showed correlations of $r = .399$ and $r = .469$ between adaptive behavior and cognitive and language development, respectively.

Examination of the mean pre-test scores among the three treatment groups revealed apparent differences. To evaluate the differences between the groups, a one-way ANOVA was conducted for each of these variables. The results of the ANOVA for Bayley Language Subscale indicated that there was a statistically significance difference between the three groups ($F (2, 138) = 35.702$, $p = < .001$). Similarly, the analysis for the Bayley Cognitive Subscale was found between the three treatment groups ($F (2, 141) = 22.362$, $p = .001$) (Table 3, Figure 1).

In light of the pre-test differences in the two dependent variables of interest and the two control variables, a one-way ANCOVA was conducted for Bayley Adaptive Subscale Post-test and VB-MAPP Barriers Post-test controlling for baseline language skills (BSID Language), baseline cognitive development (BSID Cognitive), and the two respective baseline dependent variables (Oakes & Feldman, 2001; Porter & Raudenbush, 1987). All assumptions were met to use an ANCOVA analysis. Missing post-test data is due to absence on assessment date. Missing data was not significant with each group missing 9 post-test scores. Results of these analyses showed a significant effect of treatment type on Bayley Adaptive Post-test scores after

controlling for baseline differences [F (2, 104) = 14.55, p = < .001] and VB-MAPP Barriers Assessment [F (2, 127) = 19.409, p = < .001]. Effect sizes for treatment group on both the BSID Adaptive subscale (η^2 = .218) and VB-MAPP Barriers (η^2 = .234) are medium to small.

Bonferroni post-hoc tests showed that there was no statistically significant difference between the NET group and the NET+DTT groups on both BSID Adaptive subscale (p = 1.000) and the VB-MAPP Barriers Assessment (p = .986). Post-hoc tests showed differences between DTT only and the other two treatment groups (NET and NET+DTT) were significant (p < .001).

The adjusted post-test means show that NET treatment group had the largest increases controlling for baseline on both BSID Adaptive subscale (*M* = 77.832) (Figure 2) and VB-MAPP Barriers Assessment (*M* = 23.96) (Figure 3) followed by the NET+DTT group. Post-test means are summarized in Table 3 and Figure 2.

Discussion

These results show that adaptive behavior deficits are present in children with ASD under the age of 3. These children are also, on average, displaying high levels of maladaptive behavior that may inhibit learning and teaching. To ensure change in adaptive behavior were not influenced by cognitive and language development these scores were used as covariates in the analysis. Though the results are limited due to the quasi-experimental nature of the study, NET and NET+DTT provided the most effective treatment in increasing adaptive skills and decreasing maladaptive behavior that represent barriers to learning and teaching in comparison to the DTT alone condition.

Adaptive Behavior in Toddlers

This study demonstrates the importance of measuring adaptive behavior in young children with ASD. Toddlers under 36 months of age displayed significant delays in adaptive

behavior, on average, measuring 3.5 standard deviations below the population mean. These findings support existing literature that adaptive behavior interventions are necessary for children under the age of 3 diagnosed with ASD due to emerging delays in adaptive behavior in comparison to typically developing peers (Paul et al., 2014; Ray-Subramanian et al., 2011; Ventola et al., 2011). This is especially important given that adaptive behavior is one of the two criteria for making a diagnosis of intellectual disability. The theory by Neidert et al. (2010) that children with ASD may demonstrate more barriers to learning than typically developing peers was also supported with the participants showing high levels of behaviors inhibiting learning at baseline on the VB-MAPP Barriers Assessment. Treatment approaches to teaching adaptive behavior need to incorporate both direct instruction of adaptive skills such as communication, play, and daily living skills as well as decreasing the maladaptive behavior that prevent learning and skill acquisition.

Effectiveness of NET + DTT Approach

Few studies focus on the acquisition of adaptive behavior in the early childhood population. This research, using a relatively large sample size, establishes that children who received NET alone and NET+DTT demonstrated a statistically significant improvement on Bayley Scales of Infant Development-III Adaptive Behavior Subscale and the VB-MAPP Barriers Assessment compared to the DTT alone condition after an average of 260 sessions. This research presents the effect of ABA treatment in a real world, rather than laboratory, setting, thereby theoretically increasing the external validity of the findings by eliminating the possible reactive effects of experimental arrangements (Campbell & Stanley, 1963).

Previous literature has hypothesized the need to consider the unique benefits of NET and DTT in order to tailor treatment to meet the educational and behavioral needs of the individual

child (Sundberg & Partington, 1999). This study lends quantitative evidence to the theory that NET and DTT do have differential effects on skill acquisition, specifically adaptive skill acquisition. NET was developed with a focus on teaching verbal and pre-verbal behaviors, so these findings broaden the scope of the benefits of NET and supports the current trend towards naturalistic behavioral practices (Schuck et al., 2022). The features of naturalistic interventions that this NET curriculum employ such as child-led learning, embedding instruction in the natural environment, and functionally related stimulus and reinforcement improve outcomes for young children with ASD when compared to traditional DTT alone. These results lend support for the use of NET in a community based early intervention setting, even for children who first need DTT to prepare for the instructional methods used in more natural intervention approaches. Children who first received DTT before NET scored comparatively to children who only received NET. DTT may be necessary to teach some foundational skills while NET incorporates additional generalization of skills in more typical learning environments enabling children to advance to a less restrictive preschool classroom setting.

These results should be viewed through the understanding that treatment groups differed in baseline scores that were not fully controlled for with the current statistical analysis. The findings suggest that DTT may be a vital component of the teaching protocol for children with more significant delays. Children in the DTT and NET+DTT treatment groups had the lowest baseline adaptive skill scores and highest barrier behavior scores and did not differ from one another on outcome measures of adaptive skills. The authors intended to point to characteristics of NET and DTT as contributing to treatment benefits, but quasi-experimental design revealed the significance of child symptomology and severity in moderating treatment efficacy. DTT may be a necessary component to increasing adaptive skills in children with more significant delays

and severe ASD symptoms. The DTT to NET paradigm aligns with much of early intervention clinical practice. These findings lend quantitative evidence to support that practice and support the practice, in general, of looking at different treatment modalities as parts of a comprehensive, holistic intervention plan. Shifting to viewing child characteristics as predictors of treatment efficacy aligns with much of current research on interventions for children with ASD (e.g. Jobin, 2020; Vivanti et al, 2022). The heterogeneity in ASD symptomology should be taken into account when conducting research looking at group differences in treatment outcomes.

The number of children being diagnosed with ASD is increasing every year (Maenner et al., 2020) increasing the demand for ABA therapy. Research-based decisions on how to deploy limited personnel and resources in providing effective treatment is imperative. Limited resources must be used efficiently and sparingly. Mastery of adaptive skills benefits the individual with ASD because these skills are foundational to long-term independent living, job acquisition, and interpersonal relationships. These findings lay the groundwork for further research and refinement of behavioral interventions in young children in the area of ABA and early intervention when targeting adaptive behavior.

Limitations and Future Research

Although the results reflect medium to small effect sizes, this study contributes valuable information to the field of ASD and early intervention. The community-based setting of the study is both a strength and a weakness. Random assignment of participants to each experimental group was not possible for a number of reasons. First, it is important to begin early intervention as early as possible for children with developmental delays. Deferring some children's treatment, as is sometimes possible in a randomized delayed treatment design, would not be best practice. Secondly, the policy of community early intervention programs would not permit random

assignment. Lack of random assignment can often lead to differences in baseline scores as happened in the current study. To overcome the lack of random assignment, the data collected were analyzed using pre-test scores as covariates in the statistical analysis to account for baseline differences. These procedures are commonly used in educational settings and community-based quasi-experimental research (Campbell & Stanley, 1963). Further research in this area should be conducted to rule out any confounding variables present due to lack of random assignment.

It is well documented that early intervention, using ABA principles, leads to higher adaptive skills (Eikeseth et al., 2007; Peters-Scheffer et al., 2011; Vietze & Lax, 2018; Woodman et al., 2018). Some have also theorized that multiple treatment types would be needed to provide holistic interventions (Cummings, 1999; Sundberg & Partington, 1998), but there is limited empirical evidence either comparing or favoring one ABA treatment type over another when targeting adaptive skills. In practice, children usually receive the treatment type that is most readily available to them at the time of diagnosis. These findings supports the combined approach of DTT and NET, especially for children with more significant delays in adaptive skills. A further analysis of the NET+DTT treatment condition could contribute to elucidating the dosing of NET necessary to see improvements in adaptive skills following DTT. It would be illuminating to examine trial by trial session data to further understand the impact of treatment over time. An exploratory analysis analyzing the sub scores on the BSID Adaptive Subscale could also explain the specific areas of development responsible for the improvements measured in the NET and NET+DTT treatments. It is also important to understand what features of NET (e.g., following the child's lead, functionally related reinforcement, natural environment setting) used in NET resulted in improvements in adaptive skills. Targeting intervention type and dose to identified deficits will allow the child to progress more quickly. The goal with ABA

interventions should always be treating areas of developmental delay efficiently and sustainably, creating lasting, meaningful changes over time.

Conclusion

Applied Behavior Analysis, in general, focuses on individual changes over time, tracking progress data for a single child and using single subject experimental designs. While valuable in a clinical setting, broader research identifying group differences in treatment modalities is necessary. Cummings (1999) calls for this very research approach and reminds us that, in practice, treatment modality is eclectic and varies due to the individual's acute needs. The current study demonstrates group differences of the effects of ABA treatment type specifically comparing the traditional DTT approach with NET. Children who received NET and NET + DTT showed greater improvement in adaptive behavior and reduction in barrier behaviors to learning than children who received DTT alone. Further research should be conducted to understand the teaching techniques used in NET that resulted in improvements in adaptive skills and the role of DTT in adaptive skill acquisition for children with more significant delays. A refinement of dosing recommendations is also needed to understand the relationship between the child's delays and the amount of NET or DTT needed to develop and sustain skill acquisition to provide long-term benefits. The findings of the current study inform best practice for increasing adaptive skills in young children diagnosed with ASD and broaden the methodological scope of ABA research.

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Table 1

Comparison of Features in DTT and NET Classrooms

	DTT	**NET**
Teaching Techniques	Massed trials 1:1 Instruction (teacher: student) Most to least prompt hierarchies Teacher led FBA to identify reinforcers	Embedded instruction Limited 1:1 instruction Environmental arrangements Least to most prompt hierarchies Child led Functionally related stimulus and reinforcement Environmental arrangements
Physical Environment	Table with 2 chairs Modular dividers Limited group activities	Open classroom Play stations (e.g., kitchen, block area, puzzle area) Tables and chairs
Activities (based on child's VB-MAPP skill levels)	Tabletop activities Structured programming	Group instruction/activities Cooperative play Peer interaction
Materials/ Stimuli	Stimulus picture cards Puzzles Blocks Selected toys (e.g., play phone, dolls, figurines, Legos) Fine motor toys (e.g., string cards, Silly Putty, Playdough)	Play centers (kitchen, work bench, sand table) Paper/crayons/markers Open play carpet

Table 2

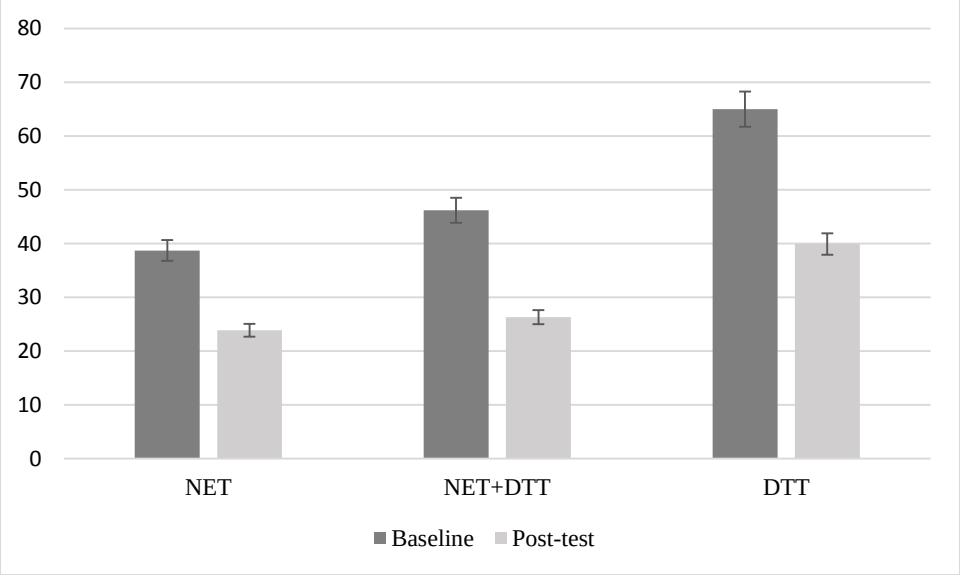
Baseline Descriptive Statistics

	BSID Adaptive	VB-MAPP Barriers
N	132	139
Mean	62.01	51.85
SD	10.66	18.26
Range	45-101	10-96

Note: Barriers sum scores range = 0-96, BSID Adaptive population mean = 100

Figure 1

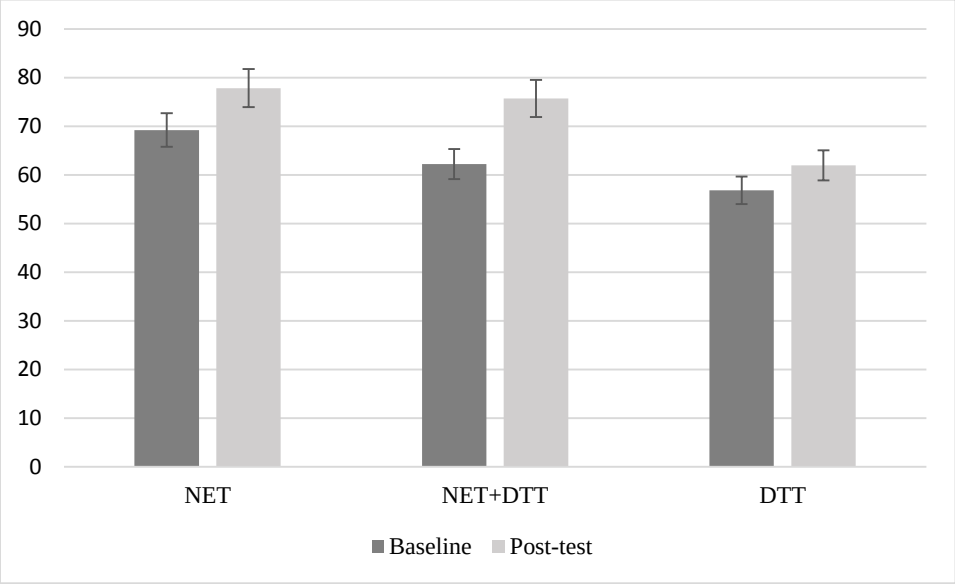
Baseline Means and Adjusted Post-test Mean for VB-MAPP Barrier Assessment



Note: Error bars represent 95% confidence interval

Figure 2

Baseline Means and Adjusted Post-test Means for BSID Adaptive Subscale



Note: Error bars represent 95% confidence interval

Table 3

Baseline Means and Adjusted Post-test Means Summary

	BSID Adaptive				VB-MAPP Barriers			
	Baseline		Post-test		Baseline		Post-test	
	M	SD	M	SD	M	SD	M	SD
NET	69.20	12.59	77.83[a]	13.28	38.72	16.12	23.88[b]	12.20
NET+DTT	62.23	8.29	75.70[a]	11.49	46.23	13.26	26.32[b]	11.05
DTT	56.82	7.00	61.93[a]	13.18	65.017	13.43	39.94[b]	12.18

a. Covariates appearing in the model are evaluated at the following values:

   BSID-Cognitive Baseline = 76.77, BSID-Language Baseline = 61.95,

   BSID-Adaptive Baseline = 62.26

b. Covariates appearing in the model are evaluated at the following values:

   BSID-Cognitive Baseline = 76.77, BSID-Language Baseline = 61.95,

   VB-MAPP Barriers Baseline = 52.229