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The Effects of Discrete Trials, Mass Trials, and Naturalistic Environment Training on General Mastered Target Behaviors in Autistic Children Using Repeated Measures

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Abstract

Introduction: Behavioral interventions based on Applied Behavior Analysis (ABA) form current evidence-based practices in treating autism spectrum disorder (ASD). Research is scarce relative to the broad effects of intensive repetitive, discrete trial training and mass trials combined with a naturalistic environment as measured by overall general target behaviors.

Methods: A repeated measures analysis tracked 93 autistic children over seven-time points during a three-month snapshot period from (3/19/23) to (6/11/23). This study used data on target behaviors to determine the effectiveness of Applied Behavior Analysis interventions combining discrete trial training, mass trials, and naturalistic environment training on mastered broad target behaviors in autistic children using a within-subjects design.

Results: Mixed (Between x Within) Analysis of Variance (ANOVA) indicated overall statistical significance across Time. Multiple comparisons showed statistical significance on all 21 multiple comparisons. There was also a significant interaction effect with (Time) x (Age category).

Conclusions: Autistic children who received applied behavior analysis combining discrete trial training, mass trials, and naturalistic environment training intervention demonstrated statistically significant improvement in target behaviors over the three-month snapshot period, the most prominent being in the (13yrs.-16yrs.) age category.

Categories: Pediatrics, Psychology, Therapeutics
Keywords: applied behavior analysis, naturalistic environment training, mass trials, discrete trial training, autism

Introduction

According to the University of California Davis Medical Center, treating individuals with autism spectrum disorder (ASD) will cost the US approximately $500 billion (about $1,500 per person in the US) by 2025. [1]. The scientific tenets of Applied Behavior Analysis (ABA) point toward ongoing evaluation of these interventions in unique settings and the individual recipient's needs [2]. Estimates show that ABA treatments, such as Early Intensive Behavioral interventions (EIBI), may save hundreds of thousands of dollars in public funds for individuals with ASD over the period that they are eligible for services under the Individuals with Disabilities in Education Act (IDEA) (Ages 3 to 22). Behavioral interventions based on ABA form the most current evidence-based practices in treating (ASD). Experimental treatments may be applied in educational, community, and Clinical settings to develop functional skills that afford as much independence as possible for individuals with ASD to live fulfilling lives [2].

Over thirty years of accumulated research suggests that applied behavior analysis ABA interventions are at the forefront of evidence-based therapy supporting the development of individuals with ASD [3]. Despite a plethora of evidence for the effectiveness of ABA, consumer concerns and misconceptions persist [4]. The National Professional Development Center on Autism Spectrum Disorder (NPDC), the National Autism Center (NAC), and various current articles recommend that consumers of ABA educate themselves on the “practice” of ABA and what constitutes effective service delivery of evidence-based interventions [4].

For many reasons, reporting of general ABA broad effectiveness with Large N designs using a mixed behavioral model, e.g., discrete trial training, mass trials, and a naturalistic environment, is needed. It can continuously inform families, educators, clinicians, and policymakers about the benefits and limitations of ABA with autistic children [5]. It can also provide evidence-based support for using (ABA) interventions as

medically necessary and reimbursable. Given the abundance of small N studies delineating the positive effects of (ABA) therapy, extensive large N studies of general ABA broad effectiveness can lead to further research to improve quality and outcomes. In addition, there is a lack of published studies using repeated measures designs.

The primary objective of this study is to extend the research to evaluate the effectiveness of a mixed behavioral model [6] using a repeated measures design with a retrospective snapshot cohort of n = 93 autistic children treated with discrete trial training, mass trials, in a naturalistic environment over seven-time points covering three months. As repeated measures indicate, it is hypothesized that the child cohorts treated with the mixed model, consisting of discrete trial training and mass trial interventions in the naturalistic environment, will demonstrate statistically significant progress toward general target behavioral goals over time.

Materials And Methods

General target mastery data were collected daily by a team of multiple (3-5) behavioral technicians per child for 93 autistic children using a large N design [5] via retrospective chart reviews contained within the “Catalyst” tracking software. Behavior analysts administered a mixed model of discrete trial training, mass trials, and naturalistic environment treatment for three months between 3/19/23 and 6/11/23.

Catalyst is a commercial electronic data collection tool that assists interventionists with capturing and analyzing copious quantities of behavioral data in a way that replicates how behavior technicians collect conventional paper data collection. Board Certified Behavior Analysts (BCBAs) created a treatment plan for each child and implemented programs and data collection methods for behavior reduction and skill acquisition [7].

Behavior technicians assigned to specific autistic children used real-time data-stamping procedures to enter data the second the data was collected. The behavior technician created an operational definition for the problem behavior and selected from continuous (frequency, duration) measurement systems using a portable electronic device (an iPad). Researchers then had access to those data online for analysis and reporting.

All autistic children were seen and treated at The Oxford Centers (TOC; Brighton and Troy, Michigan, USA), specializing in the mixed methods approach to ABA utilizing discrete trial training, mass trials, and naturalistic environment training treatment modalities. Before training, each child received a treatment plan developed by one of eight BCBAs based on the child’s needs and goals. The child was assigned to one of 83 behavioral technicians and had a 3 to 5 behavioral technician team over the three months. Appropriate materials were selected and set in rooms where individual discrete trial training and mass trials occurred or in a naturalistic setting where the child interacted with others and experienced functional and meaningful real-world situations. Each behavioral technician was assigned to a different child daily, receiving, on average, 4-7 hours of treatment per day for a minimum of 25 hours a week.

Behavioral technician teams gathered specific behavioral and skill data relative to antecedent, behavior, and consequences of behavior, noting progress and fading prompts and reinforcements as the child attempted to master the skill and whether the child was generalizing and maintaining the skill. Data was entered into a handheld “Catalyst” database and aggregated and updated daily into a central database.

The dependent variable was the multiple rater composite of the number of aggregated general target behaviors mastered measured at seven time points (Time 1-Baseline, Time 2, Time 3, Time 4, Time 5, Time 6, and Time 7) every two weeks over the three months. In a broad sense, these “general aggregate target behaviors,” as defined by BCBAs and Behavioral Technicians at the Oxford Center, involved daily living skills, including daily repertoires, organization, time management, eating-related skills, toileting, and hygiene routines. Children learned expressive communication skills, which involve speaking with words and phrases, expanding vocalizations to using more complex vocabulary, improving conversational skills, greeting people, responding to greetings, asking for assistance, and requesting things. Receptive language skills were also emphasized, such as following directions and identifying stimuli upon request.

Social skills were trained, including taking turns playing with friends, sharing, displaying assertiveness, interacting with peers, and responding appropriately to new people. Community skills in naturalistic environments involve responding to a cashier in a store, purchasing items, money management, shopping for groceries, ordering food in a restaurant, speaking to a policeman, safe walking on a sidewalk, safe playing at a park, and safety skills with strangers.

The independent variable was time, with seven levels (Baseline (Time 1), Time 2, Time 3; Time 4, Time 5, Time 6 and Time 7). Given that each child’s treatment plan varied, in a general sense, the mixed model treatment administered consisted of discrete trial training combined with massed trial instruction and a naturalistic environment treatment, with reinforcers chosen for strength, clear contingencies, and repetition to teach new behaviors.

Lucielli [8] noted that naturalistic teaching promotes the generalization of skills to everyday settings where those skills are required, thus enhancing the generalization of language, social, and play skills. Compared with more structured approaches, naturalistic teaching better generalizes critical skills to the natural setting. These procedures happen within the context of everyday activities, making learning more fun and enhancing the child's willingness to engage in learning.

This instills confidence that these procedures are a viable, evidence-based method in providing therapy to autistic children. ABA interventionists teach responses, creating contact with natural reinforcers, allowing the child's interests to direct and pace teaching. Naturalistic environments also embed education within everyday activities, incorporating prompts to be transported to new situations. Some skills can be learned in a controlled setting before transitioning to a naturalistic setting [8].

This retrospective-repeated measures design used a One-Group Pretest-Posttest Design [9], which will assess the clinical application of ABA with functional analysis and discrete trial training in a naturalistic setting to increase the occurrence of target behaviors and decrease problematic behaviors with a three-month snapshot (3/19/23 through 6/11/23) sample. Repeated measures deal with outcomes measured on the same experimental unit at different times or under other conditions,with each child serving as their control [10,11].

A retrospective power analysis was conducted using GPower 3*1 [12] and indicated n = 14 participants would be required to demonstrate a high group effect size (.80) with an alpha (α) = .05 using a Mixed (Between x Within) Analysis of Variance (ANOVA), with a power equal to .9938. Given these parameters, an acceptable sample size criterion is highly likely.

IBM SPSS Statistics (Version 29.0) [13]. was used for all descriptive and inferential statistics. Alpha (α) was set at .05. If p-values are less than .05, a null hypothesis will be rejected, and statistical significance will be implied. Demographics and baseline characteristics were summarized. Summary statistics for the categorical variables gender, race/ethnicity, and the continuous variables age, Time 1, Time 2, Time 3, Time 4. Time 5, Time 6, and Time 7 (mean and standard deviation, median, range, and skew) were generated.

A Mixed (Between x Within) Analysis of Variance (ANOVA) was used to determine the overall statistical significance between the (Time 1 to Time 7) measurements, as well as any interaction effects. If an overall significant omnibus F statistic was detected ($p < .05$) within the Mixed (Between x Within) Analysis of Variance (ANOVA), a step-down analysis was performed using resampling multiple comparison procedures in the form of bootstrapped paired tests (1000 replications). Using bootstrapping with paired t-tests, resampling methods mitigate potential multiplicity, thereby reducing familywise error rate (FEW) likelihoods [14].

The Bonferroni correction was also used as the as $\alpha = .05/21 = .0024$. Therefore, with these multiple comparisons, if $p < .0024$, a null hypothesis was rejected, and statistical significance was inferred [14]. If an overall significant omnibus interaction F statistic is detected ($p < .05$) within the Mixed (Between x Within) Analysis of Variance (ANOVA), a step-down analysis will be performed using Interaction Contrasts comparing the between subjects' factor with the within subjects' factor to determine precisely where the significant differences (effects) came about [10]. Effect sizes in the form of Cohen's d were also reported, and threats to internal validity were noted [15,16,17].

Each score (n=93) in the dataset was an equally weighted composite score of the number of aggregated general target behaviors mastered, measured at seven time points, which were the average of the multiple (3 to 5 behavioral technician) ratings. Interclass correlations (ICC) were used to measure the degree of agreement between the multiple raters, contributing to the seven timepoint composite variables.

A Two-Way Random Effects Model was computed where people's effects and measures effects are also random. We used ICC (2), which is used when multiple measurements are made from each averaged rater. The ICC (2) value was .860 (95% CI: .758-.915), indicating excellent agreement between the raters. This value was more significant than the average Pearson r (.750), suggesting that the ICC (2) was more sensitive to the variability among raters and measurements. Cronbach's alpha for the seven time point variables was r = .91 indicating a high internal consistency reliability.

Results

For the sample of 93 autistic children (M =8.8817, SD =8.05), the median was 7, the minimum was 1, and the maximum was 73. The were 74 males (74.7%) and 25 females (25.3%). There were 72 whites (72.0%), 12 Asians (12%), 5 American Indian/Alaska Native (5.0%), 4 Hispanics (4.0%) and 7 Unspecified (7.0%). There was one missing value. In terms of age categories, 18 (19.4%) were in (1yr.-4yr.) class, 39 (41.9%) were in the (5yr.-8yr.) category, 20 (21.5%) were in the (9yr.-12yr.) category, 12 (12.9%) were in the (13yr.-16yr.) category, 4 (4.3%) were in the (17yr.-73yr. category). There were four subjects over 17 years old, i.e. 18 yrs. old, 20 yrs. old, 25 yrs. old, and 73 yrs. old.

Descriptive statistics for Baseline-Time 1, Time 2, Time 3, Time 4, Time 5, Time 6, and Time 7 measurements are presented below in Table 1. Please note mean and median increases proceeding from Time 1 to Time 7.

Table 1: Descriptive statistics for repeated measurements.

		Targets Mastered Time 1-Baseline	Targets Mastered Time 2-2 Weeks	Targets Mastered Time 3-4 Weeks	Targets Mastered Time 4-6 Weeks	Targets Mastered Time 5-8 Weeks	Targets Mastered Time 9-11 Weeks	Targets Mastered-Time 7-12 Weeks
N	Valid	93	91	91	91	90	92	92
	Missing	7	9	9	9	10	8	8
Mean		1.3226	3.9670	7.7143	13.3874	17.5250	21.1593	27.1332
Median		.0000	2.0000	4.0000	8.0000	11.0000	12.0000	18.0000
Std. Deviation		2.56401	4.88581	9.64657	16.35497	19.60423	22.42591	26.56894
Skewness		2.560	1.444	1.809	1.840	1.654	1.360	1.451
Std. Error of Skewness		.250	.253	.253	.253	.254	.253	.251
Minimum		.00	.00	.00	.00	.00	.00	.00
Maximum		13.00	19.00	47.00	70.00	90.00	102.00	128.00

TABLE 1: Descriptive statistics for repeated measurements

Mixed ANOVA - Main Effects

There was a significant main effect (Sphericity assumed) on the dependent variable (General Targets Mastered) across Time, $F(6,474) = 45.447$, $p < .001$, Partial Eta Squared = .365), indicating an overall statistically significant effect (increase in general targets mastered) across the seven timepoints (levels) of the independent variable (Time). The Partial Eta Squared of .365 also indicates a large effect size.

Post hoc analyses

Post hoc analysis was conducted using a Bootstrapped (1000 replications) paired t-test for multiple comparisons with a Bonferroni corrected (.05/21) $\alpha = 0024$. The 21 multiple comparisons are presented in Table 2 below.

Timepoint	Mean Difference	Standard Error (SE)	t	(df)	p-value (Two-tailed)	95% (CI) for Mean Difference	Cohen's d
1 vs 2	-2.644	.375	-7.05	89	< .001	-3.48, -1.94	-.743
1 vs 3	-6.334	.875	-7.24	89	< .001	-8.27, -4.78	-.763
1 vs 4	-12.025	1.602	-7.51	89	< .001	-15.22, -9.26	-.791
1 vs 5	-16.158	1.937	-8.34	89	< .001	-19.97, -12.82	-.879
1 vs 6	-19.606	2.214	-8.75	89	< .001	-23.89, -15.70	-.992
1 vs 7	-25.287	2.693	-9.60	89	< .001	-31.13, -21.09	-1.012
2 vs 3	-3.689	.692	-5.33	89	< .001	-5.08, -2.41	-.562
2 vs 4	-9.381	1.452	-6.50	89	< .001	-12.26, -6.93	-.681
2 vs 5	-13.514	1.772	-7.63	89	< .001	-16.87, -10.57	-.804
2 vs 6	-16.961	2.071	-8.19	89	< .001	-20.76, -13.44	-.863
2 vs 7	-23.203	2.513	-9.23	89	< .001	-28.05, -18.78	-.973
3 vs 4	-5.692	.990	-5.75	89	< .001	-7.80, -3.98	-.606
3 vs 5	-9.825	1.296	-7.58	89	< .001	-12.47, -7.53	-.799
3 vs 6	-13.272	1.627	-8.16	89	< .001	-16.26, -10.29	-.860
3 vs 7	-19.514	2.108	-9.26	89	< .001	-23.63, -15.54	-.976
4 vs 5	-4.133	.563	-7.34	89	< .001	-5.22, -3.21	-.774
4 vs 6	-7.581	.975	-7.78	89	< .001	-9.38, -5.79	-.820
4 vs 7	-13.822	1.526	-9.06	89	< .001	-16.95, -11.00	-.955
5 vs 6	-3.448	.624	-5.52	89	< .001	-4.66, -2.34	-.582
5 vs 7	-9.689	1.253	-7.73	89	< .001	-12.48, -7.46	-.815
6 vs 7	-6.242	.928	-6.63	89	< .001	-8.28, -4.60	-.709

TABLE 2: Post-hoc Analysis with Bootstrapped Paired t-tests and Effect Sizes using Cohen's d

Results indicated that for all 21 comparisons across the independent variable (Time) dimension, all p-values were < .05 and were statistically significant at $\alpha = .05$. All effect sizes, as reported by Cohen's d, were > .550, indicating medium to large effect sizes.

Mixed ANOVA - Interaction effects - Time x Age

There was a significant interaction effect (Sphericity assumed) on the dependent variable (General Targets Mastered) across the Time and Age category, $F(24,474) = 2.961$, $p < .001$, Partial Eta Squared = .130), indicating a statistically significant interaction effect detected across the seven timepoints of the independent variable (Time) with (Age category). Statistically significant effects were detected in the toddler (1yr.-4yr.) and adolescent (13yr.-16yr.) age groups. The Partial Eta Squared of .130 indicates a large effect size.

Discussion

Discrete Trial Training is an applied behavior analytic modality that simplifies complexity by taking large, gross tasks, reducing them to small, individualized tasks, and teaching them with straightforward and systematic methods. Mass Trials are a method within discrete trial training that includes repeatedly presenting the same stimulus until the learner responds correctly. Naturalistic Environment Training is a form of ABA that teaches behavioral skills within the natural context of a learning environment. The respective learner's individual preferences and partialness serve as the motivation. The effects of a blend of discrete trial training, mass trials, and naturalistic environment training in autistic children are noteworthy as they can assist with various aspects of learner cognitive, language, social, and adaptive skills development. The benefits of discrete trial training include helping autistic children learn appropriate

responses to different situations, which can enhance communication, their relationships with family, classmates, and peers, and overall quality of life. Acquisition of skills such as matching, discrimination, and imitation using this form of (ABA) can enhance learning that is difficult to acquire in naturalistic settings [18-25].

Mass Trials assist autistic children with acquiring new behaviors more quickly and efficiently as exposure to the same or similar stimulus increases. This ABA method can help increase and retain learned behaviors over time by strengthening memory and improving recall abilities.

Naturalistic Environment Training (NET) assists autistic children with generalization skills transferred from discrete trial training to different contexts, including people, materials, and settings. NET also helps with increased motivation, spontaneity, and engagement by utilizing reinforcements that occur naturally and are aligned with learner interests.

Given the general steady increase in our study with general target mastery over the designated three-month time points, precisely, the prevalence of effects during the toddler (1yr.-4yr.) and adolescent (13yr.-16yr.) period, discovered with the interaction effect, an exploratory hypothesis may be put forth for future research. Inquiry into the different ages of participants is also needed [5]. Despite this, the statistically significant effects found in toddler (1yr.-4yr.) and adolescent (13yr.-16yr.) age categories may be a chance occurrence and the result of a biased situation inherent with convenience samples [26-30]. This interaction effect needs to be interpreted cautiously as it may result from a Type I error.

Ongoing studies of general ABA broad effectiveness, namely, with discrete trial training, mass trials, and naturalistic environment training, with Large N studies, can lead to further research to improve quality and service. This study served to address consumer concerns and misconceptions and inform consumers on the “practice” of ABA and the effective service delivery of evidence-based therapies as requested by The National Professional Development Center on Autism Spectrum Disorder (NPDC)[31].

This research is consistent with The National Professional Development Center on Autism Spectrum Disorder (NPDC), the National Autism Center (NAC), and various current articles advising consumers of ABA to become well-versed on the “practice” of ABA and the characteristics of effective service delivery of evidence-based behavior analytic interventions. These recommendations can continuously inform families, educators, clinicians, and policymakers about the benefits and limitations of (ABA) with autistic children. Research must continue to support evidence-based practices and continued improvement [5].

Limitations

Although the findings of this research are informative, it is essential to point out its limitations. A non-random sample was used for this study; therefore, there is no ability to generalize beyond this sample. Due to data constraints, there is no delineation of possible statistically significant differences between the groups relative to discrete trial training, mass trials, and naturalistic environment training.

Seven threats to internal validity apply in pre-experimental research designs of this type. History points toward extraneous variables not part of the study or any external events that may affect outcomes. Maturation involves age-related bodily changes and includes age-related physical changes that can occur with time, such as hunger, tiredness, fatigue, wound healing, surgery recovery, disease progression, etc. Testing relates to the notion that the test may affect the children’s responses when tested again. These are less of an issue when the tests are routine. Instrumentation refers to any change in measurement ability, including any judge, rater, etc. Statistical Regression is the tendency for individuals who score extremely high or low on a measure to score closer to the mean of that variable the next time they are measured on it. Selection refers to the potential bias in selecting participants who will serve in the experimental and control groups. Mortality refers to the differential loss of study participants, drop-out rate, or attrition. [17]. This is a within-subjects design, whereby each subject serves as its control., therefore, there was no control group utilized for ethical purposes.

Also, this is a snapshot study that covers three months, and it will be informative to assess these research subjects over a longer time longitudinally. This paper uses retrospective data, and while the single group pre-post design is pre-experimental, a prospective study is warranted for future investigation. Ethical issues preclude utilizing a control group (no treatment) for autistic children. Also, there appears to be a need in the literature concerning the analysis of discrete trial training and naturalistic environment training with repeated measures that calls for future inquiry.

Conclusions

The study's primary objective was to evaluate a mixed applied behavior analytic model's effectiveness, combining discrete trial training, mass trials, and a naturalistic environment on the number of aggregated general target behaviors mastered in autistic children using a repeated measures analysis. This is the first piece of research utilizing a mixed model of discrete trial training, mass trials, and naturalistic environment

treatment with a measured effect on general target mastery information using a large N design with repeated measures. The statistical results showed that these interventions significantly increased general aggregate target behaviors over seven-time points. We observed statistically significant increases in mean and median measurements of the number of multiple raters composite general target behaviors achieved per session. The multiple comparisons between time points indicated an upward trend of improvement and statistically significant differences between time points with medium to large effect sizes, the most prominent being in the (13yrs.-16yrs.) age category.

Additional Information

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. WCG-IRB issued approval 1-1703366-1. The authors declare that this research investigation involves minimal risk, as no identifying information in the text appears in the article. Informed consent has been waived compliant with the Belmont Report Regulations 45 CFR 46 2018 Requirements (2018 Common Rule) Section 46 Subpart A Basic HHS Policy for Protection of Human Research Subjects, 46.104 Exempt Research Paragraph d (1), (2), and (2) ii and 46.117 Documentation of Informed Consent Paragraph c (1) (ii). This study also conformed to the guidelines outlined in the 1964 Declaration of Helsinki. . **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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