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Research Article

Supporting Young People on the Autism Spectrum: Analyzing the Effectiveness of Components of Habit Reversal Treatment

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Abstract

Habit Reversal Treatment (HRT) has been used successfully to reduce nervous habits and tics in neuro-typical children and adults. It has not been researched extensively with regards to the restricted and repetitive behaviors that are part of a diagnosis of autism. This paper reports on the effectiveness of each of the three main components of HRT for young people on the autism spectrum. The awareness training procedure was effectively used in the treatment of encopresis; the competing response procedure effectively used in addressing vocal tics; and the social support procedure was effectively used for caregiver training to enhance overall treatment outcomes. Results are discussed in the context of evidence-based practice.

Keywords: Autism; Habit Reversal Treatment (HRT); Applied Behavior Analysis (ABA); Record review; Component analysis

Introduction

Habit Reversal Treatment (HRT) was administered originally to individuals who exhibited various tic behaviours including sudden movement of the head, shoulders, neck, and elbows, fingernail biting, thumb sucking, grasping objects, and clenching fists [1]. Initially, HRT consisted of nine steps:

1. In the response description procedure, each participant described and physically demonstrated the target behaviour.
2. In the response detection procedure, the participant described the occurrence of the target behaviour each time it occurred.
3. The early warning procedure required participants to identify the earliest step in the target behaviour, such as moving their hand to their mouth to bite their nails.
4. Competing response practice required the participant to perform another behaviour instead of the target behaviour contingent upon the earliest detected step in the target behaviour. Specifically, the other behaviour had to oppose the physiological movement of the target behaviour, be performed for three minutes, tense the muscles involved in the target behaviour, not include any socially stigmatizing movement, and strengthen opposing muscle groups to those used to perform the target behaviour.
5. For situation awareness training, the participant described how the target behaviour occurred across previous situations, people, and places.
6. Habit inconvenience review consisted of an intraverbal exchange between therapist and participant, describing observable barrier and private emotional behaviours consequent to the target behaviour.

7. In the social supports procedure, following demonstration of all previous steps in habit reversal, training was provided to the participant's significant others to deliver verbal praise in the absence of the target behaviour when the competing response was observed. The social supports procedure further required caregivers to ask the participant to perform the competing response contingent upon the early signs of the target behaviour. Also included were telephone calls from the therapist to collect data outside of practice in the clinic on a fixed interval schedule along with therapist- provided verbal praise for participants collecting data.
8. During the public display procedure, data on target behaviours collected in the social supports procedure were reported to the participants friends, co-workers, or teachers.
9. Lastly, the symbolic rehearsal procedure was a generalization procedure where the participant was verbally instructed to privately visualize a contingency where the target behaviour was likely to occur, and vizualise detection of the target behaviour and engagement in the competing response..

Results of this procedure were highly significant and, regardless of age or gender of the participants, for 95% of participants behaviour reduction was achieved after only one day of training, for 99% of the participant, target behaviours decreased after three-weeks of intervention. Each intervention sessions lasted no more than one-hour [1]. The strong outcomes of the initial HRT procedure fueled further research into whether or not a less complex combination of steps could yield similar outcomes. However, findings led to little agreement as to the essential components of a habit reversal procedure. For instance, Dutta, et al., screened 112 papers and found only 5 studies that had used awareness and competing response training [2]. Nunn, et al., reported that they trained 13 participants, aged 11-38 years, in self-monitoring and competing response contingent upon a privately experienced drive or engagement in finger nail biting [3]. For a competing response, participants were taught to manicure their own finger nails or to grasp an object, or clench their fists for three-minutes. Nail biting reduced and results were maintained for all participants through 16-week follow-up. Horne, et al., trained participants in a response detection procedure, and, in addition to recording the length of nails, noted their mood, date, time, place, and duration of nail biting [4]. Results were similar to those of Nunn, et al., [3].

Miltenberger, et al., included nine participants with muscle tics who were assigned to either a shortened version of HRT that included awareness and competing response training only (n = 5) or the full HRT procedure (n = 4), consisting of awareness training, verbal review of the inconveniences posed by the target behaviour, relaxation training, competing response training, and provision of social supports [5]. Results for all participants in the shortened procedure showed decreased frequency of target behaviour that was maintained at seven and 15-week follow-up. For those who received the entire habit reversal procedure, two participants' target behaviours reduced immediately and dramatically, one participant demonstrated a gradual reduction of the target behaviour, and for one participant the frequency of muscle tics did not change.

To confirm that the effectiveness of HRT is not dependent upon all nine original intervention components, Woods, et al. completed a literature review and found the essential components of HRT to be awareness training (also referred to as self-monitoring) and competing response training [6]. For example, they reviewed Ladouceur who had trained a cohort of nine participants over four-weeks in self-monitoring for nail-biting [7]. Chi-square analysis showed that self- monitoring reduced behaviour similarly to cohorts who received all nine HRT steps. They also analysed Ollendick who provided self-monitoring training to a nine-year-old male with repeated eye blinking and found that eye-blinking reduced by 50% with self-monitoring alone [8]. In Wright study, head movement tics of a 19-year-old college student reduced with self- monitoring alone from a baseline of 54% of 12-second intervals to 15% of 12-second intervals following intervention [9]. For the same participant, eyebrow raising tics reduced from 57% at baseline to 15% (of 12- second interval recordings) following intervention. These results generalized to the natural environment. In Dillenburger HRT was used with a 13-year-old girl for tic behaviours [10]. Specifically, the implementation of self-monitoring as a response detection in a young child was successful in decreasing her tic behaviours.

Research on the inclusion of the social supports procedure shows that it may not be necessary for adults but that it is necessary with children. For instance, Flessner, et al. randomly assigned 40 college-aged participants who engaged in nail-biting to either an awareness training with competing response group or a simplified habit reversal group [11]. In the simplified habit reversal group participants were instructed to identify a support person to participate in the study with them. Results showed that participants in both groups saw a 61% decrease in nail biting from baseline to post- intervention with an additional 45% decrease from post-intervention to follow-up. In contrast, Wagaman, et al., trained the parents of 8 children, aged 6-10-years-old in HRT [12]. The children in this study exhibited stuttering behaviours and parents were instructed to implement intervention at home. Following intervention, stuttering decreased in all 8 participants to below 3% of stuttered words and was maintained at 10-13-months follow-up. Parent ratings of the procedure showed it to be acceptable (above the cutoff score of 27 on the Treatment Evaluation Inventory and credible (above the cutoff score of 28 on the Treatment Credibility Inventory) [13,14]. Woods, et al., explored various other combinations of HRT with children with frequent motor tics in a mixed multiple baseline across participants and behaviours design using interval recording [15]. Phases included awareness training;

awareness training and self-monitoring; awareness training, self-monitoring, and social supports; and awareness training, social supports, and competing response training. They demonstrated the importance of selecting HRT components based on the needs of the individual and that awareness training, competing response training, and social supports seemed to be crucial elements to HRT.

Aside from variations in HRT procedures, the specific procedural instructions have also been examined. Sharenow, Fuqua, et al. noted that the type of competing response was not crucial for muscle tic suppression, noting that the competing response did not have to function as an incompatible behaviour [16]. Their findings were confirmed by Woods, et al., who compared competing responses that were similar and dissimilar for thumb-sucking behavior [17]. In the similar competing response group, participants were taught to clenched fists while participants in the dissimilar competing response group were to clench their knees. Awareness training and social supports were administered for both groups. Findings showed that HRT was effective whether the competing response was similar or dissimilar.

Twohig, et al. [18] compared competing response durations regarding nail biting.

Competing response duration varied between 5-seconds (5s), 1-minute (1m), and 3-minutes (3m). While all three durations led to short-term intervention success, at 3-month follow-up results were maintained only for the 1m and 3m groups, highlighting the importance of sustained engagement in the competing response.

An evaluation of the difference between contingent vs non-contingent competing responses was conducted by Miltenberger, et al. [16]. For the contingent competing response, participants engaged in an incompatible competing response for 3-minutes following performance of the target behaviour. In contrast, the non-contingent competing response participants practiced the competing response three times per day non-contingent on the target response for as long as they had engaged in the target behaviour during baseline (i.e., the average duration of target behaviour during baseline). Results showed that the contingent competing response reduced behaviours significantly from baseline across all participants.

A review of component analyses of HRT was undertaken by Miltenberger, et al. [19]. They reiterated that habit behaviours were defined as repetitive or stereotyped behaviors with negative physical or social consequences for the individual. For the most part, these behaviours are maintained by automatic reinforcement contingencies, however, social reinforcers also play a role in maintaining some repetitive behaviours. They found that most successful habit reversal procedures include only 3 of the main components, i.e., some form of awareness training, competing response training, and social supports. Miltenberger, et al. noted the lack of research using HRT with older, neuro- atypical participants and behaviours besides nervous habits and tics.

With this in mind, the current study focusses on young people on the autism spectrum and reports on data that were recorded between 2017-2020 at an Applied Behaviour Analysis (ABA) unit of a large hospital in the USA [20]. The study highlights individual components of HRT including awareness training, competing response training, and social supports training to address the following research questions:

1. Is HRT a viable intervention for people with repetitive and stereotyped behaviours commonly associated with autism?
2. What are the components of habit reversal that were used in interventions to support individuals on the Autism spectrum?
3. Do the individual components of habit reversal produce meaningful change for individuals on the Autism spectrum?

Procedure

Ethical approval

This study was approved by the Queens University Belfast Research Ethics Committee (UK) and by Beaumont Health Internal Review Boards for research with human subjects (USA) and conforms to the relevant standards of data analysis and protection. The hospital's internal review board waived the requirement for individual participant consent.

General Setting

A search of file records was conducted at an ABA unit at a large hospital in a metropolitan city in Michigan, USA. The focus of the search were data that had been collected during interventions that supported individuals on the autism spectrum. The clinic where the interventions had been conducted was a multidisciplinary practice, specializing in supporting patients with medically complex needs and those with developmental disabilities. The building was arranged in a "three-armed" star pattern where each "arm" was an office suite, extending from a central industrial kitchen. The clinic consisted of an applied behaviour analysis intervention space (ABA Suite), speech and related occupational therapy in the first suite, physical therapy and related occupational therapy, and specialty medical services in the second suite, and a child care program funded by a local university in the third suite.

All interventions included in present study took place in the entire ABA Suite. This space included three, classroom-sized rooms partitioned into 6.5' wide by 7.5' long cubicles. Classroom 1 contained nine cubicles, Classroom 2 contained four cubicles, and Classroom 3 contained three cubicles. Each cubicle was furnished with a child-sized chair, adjustable height table, rolling

office chair, and various stimuli previously identified as reinforcers for the participant. Intervention space also included restrooms (a restroom off Classroom 1 and a "Jack-and-Jill" style restroom shared between Classrooms 2 and 3) equipped with a full-sized adult toilet and a smaller and shorter child sized toilet in separate stalls. The bathroom also included an adult-sized sink and counter top with soap and paper towel dispenser. Other intervention spaces included a gross motor gym with a climbing rock wall, two trampolines and two 5' by 5' blue foam-filled nylon Skil-Care Crash Pads, a Fischer Price Cozy Cabin®, and an assortment of various sized tricycles, bicycles, and play balls. A swing room was also available with access from the back of the gross motor gym. It included (from left to right) a bubbling and color- changing water tube with sea creatures inside, a bolster swing suspended from the ceiling at two points with a blue four-inch-thick cushion below, and another anchor point opposite the bolster swing for either a flat board swing or an inner tube swing with the same four-inch-thick cushion below.

Parent training sessions were conducted in a typical therapy office space about 8' x 10' in size with a Dell Laptop Computer on a desk and two comfortable chairs. Present for parent trainings typically were one or both of the parents along with their designated Board-Certified Behavior Analyst® (BCBA). Each parent training session was typically scheduled for 60-minutes.

Research Tools

Epic medical charting software. EPIC is an electronic medical record (EMR) and revenue tracking system used in intervention care facilities and out-patient clinics around the world with over 250 million medical patients currently having an Epic EMR [21]. It is used to document records of medical visits, assessments, laboratory specimens, and other medical visits and procedures. For the purposes of the present study, data were retrieved from patient medical records on the Epic EMR for patients seen for intervention using ABA between May 2017 and December 2020.

Microsoft excel 2016 is a spreadsheet software program used to organize, format, calculate, and graph data [22]. Excel provides the input user with a matrix of up to 1.048,576 rows and 16,384 columns with the total amount of alphabetical and numeric data limited by the available memory and computer system resources. For the purposes of the present study, the 2016 version was used to enter numeric data and graph intervention results for clinical decision-making.

Microsoft sharepoint is a browser-based collaboration and document management platform for centralizing and storing shared documents in a password-protected space [23]. Documents on the SharePoint system can be stored, downloaded, and edited. Data collected for this study was stored on a secure SharePoint account managed by and per the requirements of the hospital IRB.

Intervention Measures

Verbal behaviour milestones assessment and placement program (VB-MAPP) Milestones Assessment (MA). The VB-MAPP MA is an evaluation of a child's development across 15 different levels in each of 16 separate domains of language-related skills (based on B.F. Skinner's Analysis of Verbal Behaviour). Data were collected at the clinic by a BCBA with results documented in the participant's medical chart as part of their assessment and intervention plan for ABA therapy. For the purposes of the present study, data from the full MA were extracted from the EMR for each participant.

Verbal behaviour milestones assessment and placement program (VB-MAPP) barrier assessment (BA). The VB-MAPP BA is a 24-item survey of road blocks (strong or persistent negative behaviours, absent; weak; or impaired verbal operants; weak motivating operations; prompt dependency, self-stimulation, sensory sensitivities, or physical and medical problems) to a child's development. Each item on the survey is rated on a zero-to-four-point Likert scale. Greater scores on the BA individually and overall are indicative of more severe and persistent problems that delay or impair the acquisition of new skills. Data were collected by a BCBA in concert with the Behaviour Technician (BT) working with the participant with results documented in the participant's medical chart as part of their assessment and intervention plan for ABA therapy. For the present study, data for the BA were extracted, when available, from each participant's EMR.

Early Echoic Skills Assessment (EESA). The EESA is an evaluation of a child's echoic verbal operant between 0 and 30-months of development. It contains a list of 100 target sounds categorized into five groups including the first category of simple and reduplicated syllables targeting vowels, diphthongs (sounds resulting from the combination of two vowels into a single syllable where the sound starts as one vowel and moves to another. For example, the word coin.), consonants, p; b; m; n; h; and w sounds, the second category of two syllable combinations targeting consonants k; g; t; d; f; y; and ng, category three containing three syllable combinations, group four testing prosody on spoken phrases with emphasis placed on a specific syllable, and group five targeting other contexts of prosody including pitch, volume, and duration. A full point is given for correct responses, a half point for responses that add a syllable or subtract a consonant or emphasize the wrong syllable, and no points for incorrect vowels, missing syllables, or monotone responses. Scores 0 to 25 represent 0 to 18-months of development and scores 26 to 100 represent 18 to 30-months of development.

General Data Extraction Procedures

The EMR was accessed from an 8' X 10' office with a desk, comfortable chair, and Dell Latitude laptop connected to two

external monitors. Data extraction began by logging into EPIC and searching each individual's medical record. Once in EPIC, a patient's medical chart was accessed by selecting the chart button. In the pop-up window, the participant's name was entered. Next, with the participant's medical chart opened, the 'chart review' tab was selected followed by the 'encounters' sub-tab. From here, a search filter was set to include completed appointments with a chief complaint of autism, the encounter department set to the hospital's autism clinic in the city where the clinic was located. The providers were Behaviour Technician or BCBA who provided intervention at the clinic. This filter populated only the assessment and intervention encounters for ABA Therapy into a chart. The records were then ordered by date, starting with the earliest record and loading all visits by clicking the date column until the direction arrow next to date pointed downward. A hand search of each medical record on the chart was then conducted.

A total of 24 files were included in the present study. Awareness training and competing response training, had been conducted with one participant each while 22 participants had received social supports procedures. The first author had served as clinical supervisor for all cases included in the present study, including consultation on the development of the intervention plan and trouble-shooting in both the awareness training and competing response training studies. All interventions were delivered by other clinic staff; neither of the present authors had conducted the assessments, delivered interventions, or collected the data personally. Participant data sets were selected from the EMR if they met the following criteria:

1. The intervention occurred between May 2017 and December 2020.
2. Interventions had been completed prior to file search being carried out.
3. Patients had agreed to routine clinical data collection before the intervention commenced.

The relevant data were extracted and graphs were drawn and independently analyzed by the first author using the existing data sets from the EMR.

Component Study 1: Awareness Training (Response Description and Response Detection)

Awareness Training Operational Definition

Awareness training is a component of HRT that requires verbal or non-verbal identification of antecedent triggers to the target behaviour or identification of the occurrence of the target behaviour [1]. Awareness training may take the form of verbally stating that a trigger or target behaviour has occurred or some other physical indication (e.g., hand raise) that a trigger or target behaviour has occurred.

Awareness Training Participant

The file review identified one participant who had received awareness training. Calvin was a 4½ year-old male who had attended the clinic's ABA Intervention Center. His parents had reported that he had cognitive delays but they could not report the level of severity. He had received intervention for 30 hours per week and was not enrolled in any formal education program outside of ABA therapy. On VB-MAPP Assessment Calvin had scored a total of 55.5 of 170 possible points. Records showed that he manded (requested) spontaneously for at least 15 different visible items using his Augmented Communication Device (AAC). His mands on the device included at least ten different, two or more- word mands. He also could request some items that were not visibly present in the environment. There was no record of tacting (describing) having been observed. Calvin did demonstrate a variety of conditioned discriminations including selecting 250 different items when named, performing 10 different motor actions on command, and selecting items from an array of at least 6 different items.

Calvin's record showed that he had relatively strong matching skills in terms of identical and non-identical matching of ten different items along with demonstrating sorting into five different categories, and matching 2D to 3D and 3D to 2D objects in a messy array of ten different items. He did imitate novel actions by an adult model with and without objects, imitated at least 10 sequences (3 components each), and imitated a variety of gross and fine motor movements. Calvin independently assembled 5 different toy sets, demonstrated the functional use of 5 different toys, and search for missing pieces of a play set. Socially, he did respond to mands (requests) from peers and follow them in play while also demonstrating parallel play and eye contact with peers.

Calvin did not score any points on the Early Echoic Skills Assessment (EESA). Parents expressed interest in Calvin learning to remain dry and use the restroom during the day. Toilet training was critical to increasing Calvin's independence in his self-care and daily routine and to prepare him for an educational setting with minimal supports.

Target Behaviour for Awareness Training

The behaviour targeted for intervention was "dry pants", which included underwear and pants without urine or feces. Additionally, dry pants included independent and spontaneous requests to use the restroom with elimination.

Awareness Training Procedure

Awareness training occurred during Calvin's typical ABA Therapy, Monday-Friday between the hours of 9 AM and 4 PM (two, three-hour blocks of intervention from 9 AM to 12 PM and

from 1 PM to 4 PM) with an hour break for lunch between 12 PM and 1 PM. Calvin's ABA therapy programming was implemented in tandem with active therapy sessions. The goal of awareness training for Calvin was, given the private physiological sensation to eliminate, his pants would remain dry (100% of active therapy sessions) with elimination in the toilet (80% or more of active therapy sessions), across five consecutive active therapy sessions, as evidenced by percentage of dry pants checks.

From the start of the therapy day, Calvin was given free access to a child's sippy cup of his favorite juice diluted in water (about 50/50 dilution). The cup was refilled when only about a quarter of the cup of juice water mix remained. Pants checks occurred after a pre-determined amount of time (as defined in each intervention phase) with Calvin's therapist delivering the verbal SD, "It's time to go potty", each time the timer ended. These checks initially occurred every 15-minutes and increased in five-minute increments up to 60-minutes between checks. Pre-determined time between checks was increased by five minutes following at least two consecutive active therapy sessions at 100% dry pants. A return to any previous intervention phase occurred following a pants check with wet pants.

Following verbal delivery of the SD, Calvin was provided minimal physical guidance to the toilet. Provided prompts started with an indirect verbal prompt and increased in intrusiveness to a direct verbal prompt following five seconds without a response. If the direct verbal prompt also did not result in a response after another five seconds, the therapist gestured by pointing in the direction of the nearest restroom. After another five seconds without a response, partial physical guidance from the shoulders was given by the therapist, guiding Calvin to the bathroom. At the toilet, Calvin was verbally prompted to pull his pants down only if he did not spontaneously pull his pants down within 2-seconds of arriving to the toilet. Once his pants were pulled down and if his pants were clean from urine or feces, Calvin was verbally praised ("Great job keeping your pants dry!"). After the pants check, Calvin was verbally instructed to sit on the toilet. Once sitting, he was given a book or hand-held toy to play with while sitting for 5-minutes. Any elimination during the 5-minutes was verbally praised ("Awesome going on the potty!") along with tickling him or squeezing his arms or shoulders and access to jump on the trampoline for 5-minutes once the toileting procedure had been completed. If he did not eliminate, Calvin received verbal affirmation in a neutral tone ("nice trying").

Data were collected using the Toileting Data Sheet (Appendix 1). Each time the pre-determined amount of time between checks ended, Calvin's therapist recorded the date and time of the pants check, whether his pants were dry when they were pulled down, and if Calvin eliminated in the toilet. Each row on the data sheet represented a new dry pants check. The percentage of independent requests to go to the bathroom was calculated using the following formula:

$$\%\ \text{of Independent Requests} = \left(\frac{\#\ \text{of Independent Requests}}{\text{Total \# of Request Opportunities}} \right) \text{X}\ 100$$

The percentage of checks resulting in dry pants was calculated using the following formula:

$$\%\ \text{of Dry Pants} = \left(\frac{\#\text{of Dry Pants Checks}}{\text{Total \# of Checks}} \right) \text{X}\ 100$$

The percentage of eliminations in the toilet during pants checks were calculated using the following formula:

$$\%\ \text{of Dry Pants} = \left(\frac{\#\text{of Dry Pants Checks}}{\text{Total \# of Checks}} \right) \text{X}\ 100$$

All data were graphed with Session Number on the X-Axis and each of the three dependent variables on the Y-Axis, graphed separately on their own graph.

Single-subject design effect size measures including the Percentage of Non-Overlapping Data Points (PND), Mean Baseline Reduction (MBR), and Improved Rate Difference (IRD) were also calculated. These values were obtained comparing Phase 1 of intervention to the combination of all other phases of intervention. PND was calculated using the following formula [24]:

$$\text{PND} = \frac{\#\ \text{Data Points below the Lowest Baseline Data Point}}{\#\ \text{Data Points in the Phase}}$$

PND was interpreted where less than 50% concluding the intervention was ineffective, 50% - 74% equating to inconclusive results, 75% - 90% equating to an effective intervention, and greater than 90% equating to a highly effective intervention.

The MBR was calculated using the following formula [25]:

$$\text{MBR} = \left(\frac{\text{Intervention Phase Mean} - \text{Baseline Phase Mean}}{\text{Baseline Phase Mean}} \right) \text{X}\ 100$$

The MBR was interpreted where less than or equal to 50% was considered a low effect, 51% - 74% was considered a medium effect, and greater than 75% was considered a high effect.

The IRD was calculated using the following formula [26]:

IRD = b – a,

where;

a = data points in baseline that were less than or equal to exceeding any data point in intervention as an Improved Ratio (IR):

$$IR = \frac{\text{\# Improved Data Points in Baseline}}{\text{\# Total Baseline Data Points}}$$

b = data points in intervention that were less than all data points in baseline as an IR:

$$IR = \frac{\text{\# Non-Improved Data Points in Intervention}}{\text{\# Total Intervention Data Points}}$$

For interpretation of IRD scores, +/-0.50 was considered small and unreliable, scores between +/-0.50 and +/-0.70 were considered moderate, and scores above +/-0.70 were considered significant.

Awareness Training Results

A summary of each intervention phase is provided in Table 1. The percentage of pants checks with wet pants is represented in Figure 1, the percentage of independent requests in Figure 2, and the percentage of sessions with voids in the toilet in Figure 3. At the three sessions in the 15-minute interval phase, wet pants were observed 11% for Session 1, 5% for Session 2, and 0% at Session 3. No independent requests were observed across all three baseline sessions. Voids in the toilet were observed for 17% of trials during Session 1, 47% of trials during Session 2, and 45% of trials during Session 3. Training continued for a total of 172 sessions. At Phase 8, 11% of trials during Sessions 19 and 21 resulted in moving back to 45-minute intervals. Further reduction to 40-minute intervals occurred following 10% of trials with wet pants for Session 23. Phases of intervention then proceeded to increase by five-minute intervals up to 60-minute intervals. While toileting accidents were observed at 60-minute intervals, both the BCBA and parents agreed to maintain at the 60-minute intervals with the introduction of toilet training at home since parents reported that 60-minute intervals were the best they felt they could maintain at home. At Session 42, the intervention phase was increased to 90 minutes with data collected for 130 more sessions.

Phase	Description
1	15-minute intervals between opportunities to sit on the toilet
2	20-minute intervals between opportunities to sit on the toilet
3	25-minute intervals between opportunities to sit on the toilet
4	30-minute intervals between opportunities to sit on the toilet
5	35-minute intervals between opportunities to sit on the toilet
6	40-minute intervals between opportunities to sit on the toilet
7	45-minute intervals between opportunities to sit on the toilet
8	50-minute intervals between opportunities to sit on the toilet
9	45-minute intervals between opportunities to sit on the toilet
10	40-minute intervals between opportunities to sit on the toilet
11	45-minute intervals between opportunities to sit on the toilet
12	50-minute intervals between opportunities to sit on the toilet
13	55-minute intervals between opportunities to sit on the toilet
14	60-minute intervals between opportunities to sit on the toilet
15	90-minute intervals between opportunities to sit on the toilet

Table 1: Description of intervention phases in order of implementation for Figures 1, 2, and 3.

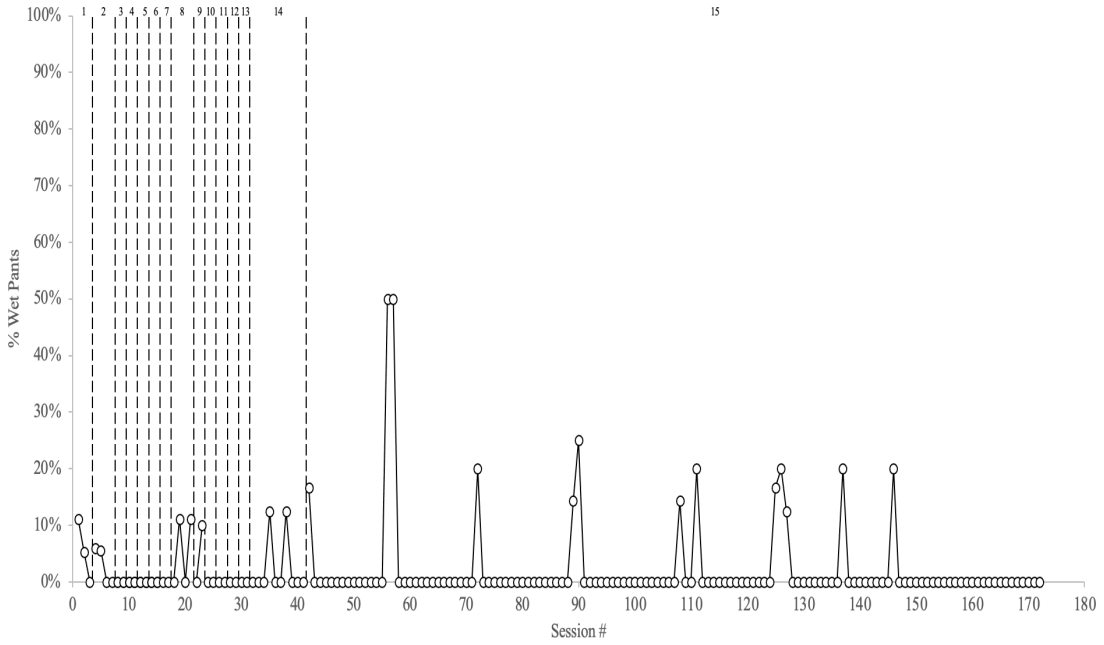

Figure 1: Percentage of wet pants checks therapy sessions.

Across all intervention phases, the number of sessions with pants checks resulting in wet pants was consistently low, with 150 (87%) sessions across all phases where pants remained dry the entire session. Analysis of the average rates of wet pants within each phase, shown in Figure 3, provides further support with positive rates of wet pants during Phases 1, 8, 9, 14, and 15. Calvin was dry during all other phases and sessions. The overall average percentage of wet pants checks was 1.57% across all phases. A spike in wet pants checks was noted during Phases 8 and 9, which occurred during the reduction from 50-minute intervals (Phase 8) to 45- (Phase 9) and 40-minute (Phase 10) intervals. A review of medical chart notes and data indicated a period of physical illness during this time with three sessions cancelled due to illness within the spike in wet pants

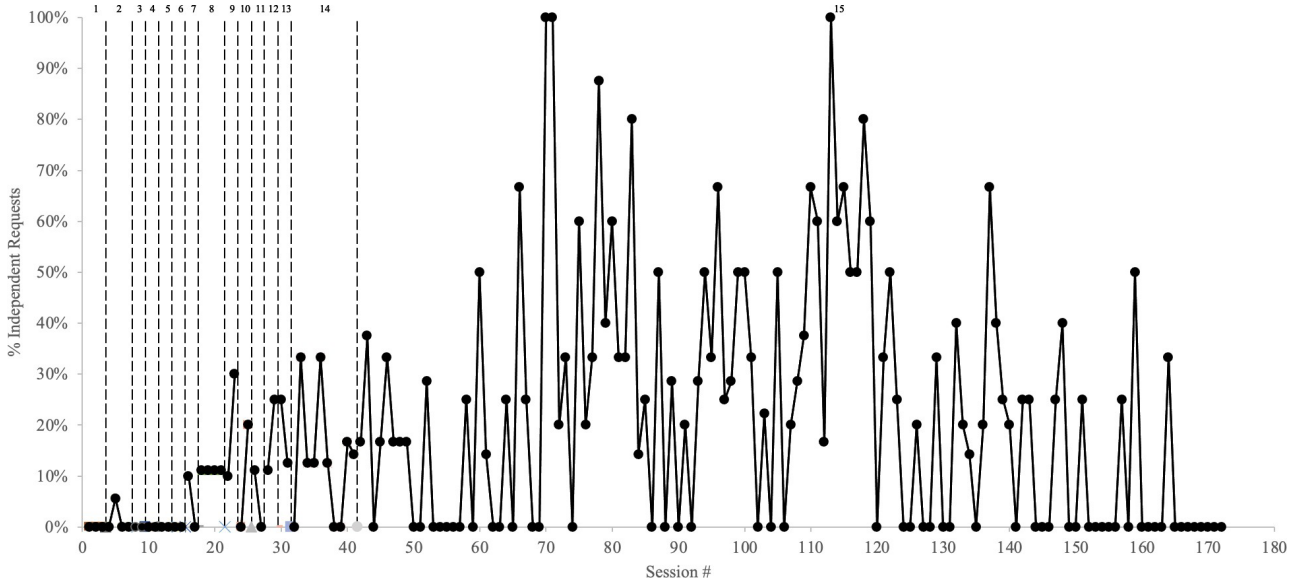

Figure 2: Percentage of independent requests to go to the bathroom per therapy sessions.

Across all intervention phases, the number of sessions with independent requesting showed an increase over sessions and phases, from no independent requests during the first three sessions at 15- minute intervals to 76 of the last 130 sessions (58% of sessions) with independent requests at 90-minute intervals (Phase 15). From visual analysis, variability was high in the percentage of independent requests, starting at Phase 7 and continuing for the rest of the intervention phases. Further examination of the average percentage of independent requests within each phase, shown in Figure 2, indicates an overall increase at a rate of 1.62% across phases or an overall increase of 23.2% from Phase 1 to Phase 15. Furthermore, of the 98 sessions reported with requesting, 86 of the sessions included requests with dry pants the entire session (88.8% of sessions with requests and dry the entire session). Also, across the 75 sessions where no requests were observed, 64 of those 75 sessions resulted in Calvin remaining dry the entire session (85.3% of sessions without requests and dry the entire session).

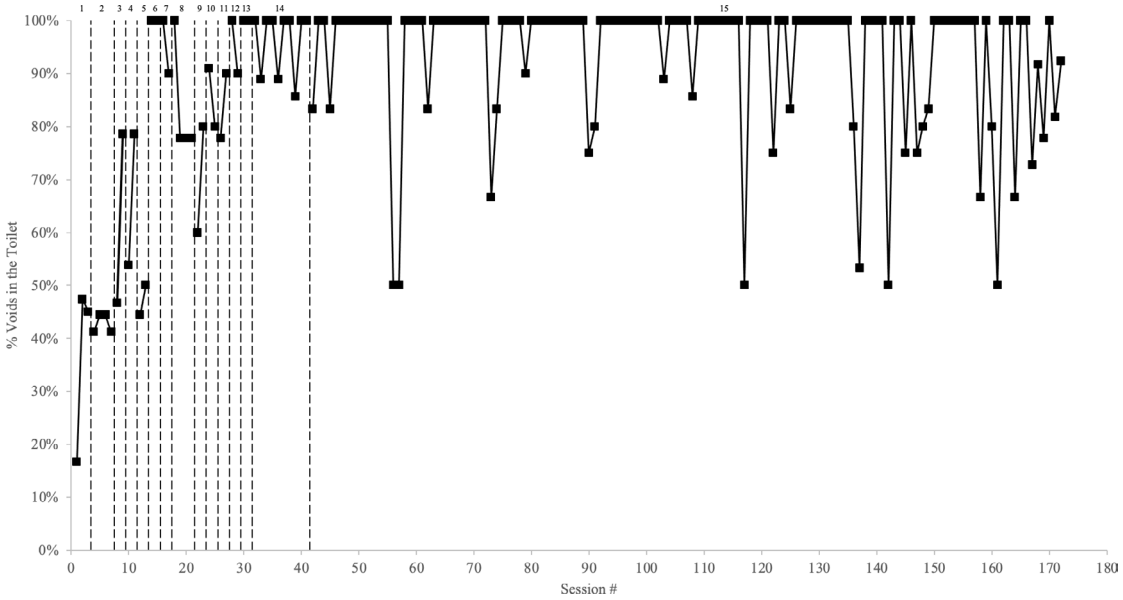

Figure 3: Percentage of voids in the toilet per therapy sessions.

Figure 3 shows the percentage of voids in the toilet across intervention sessions and the average response per intervention phase reported in Figure 3. During Phase 1 of intervention, Calvin averaged 36.3% accuracy of voiding in the toilet (17% in Session 1, 47% in Session 2, and 45% in Session 3). Accuracy of voids in the toilet increased to an average of 95% by Phase 15 with a rate of increase at 3.9% per intervention phase. During the 98 sessions with independent requests to void, all sessions resulted in some elimination in the toilet.

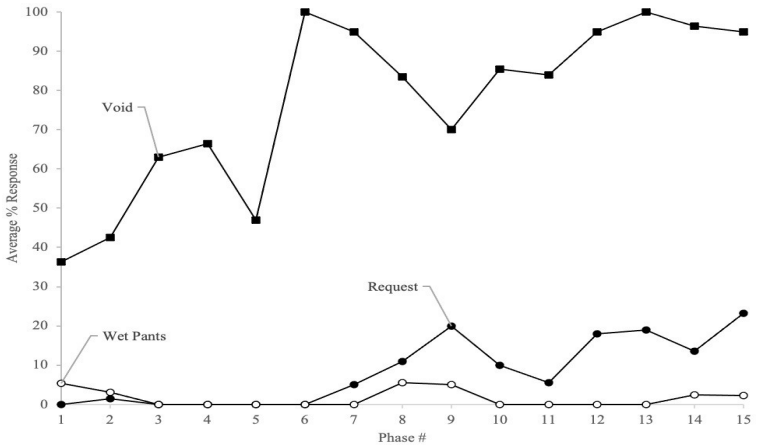

Figure 4: Average response for each dependent variable per intervention phase.

Phase	% Request	% Wet	% Void
1	0%	5.3%	36.3%
2	1.5%	3%	42.5%
3	0%	0%	63%
4	0%	0%	66.5%
5	0%	0%	47%
6	0%	0%	100%
7	5%	0%	95%
8	11%	5.5%	83.5%
9	20%	5%	70%
10	10%	0%	85.5%
11	5.5%	0%	84%
12	18%	0%	95%
13	19%	0%	100%
14	13.5%	2.5%	96.4%
15	23.2%	2.3%	95%
Total Avg.	8.4%	1.6%	77.3%

Table 2: Numerical data for each data point in Figure 4 and total average responding across all intervention phases reported in percentages.

Lastly, the PND for independent requests was questionable at 58%, effective for a reduction in wet pants at -88%, and very effective for elimination in the toilet at 96%. The MBR for independent requests was low at 20%, moderate for reduction in wet pants at -60%, and high for elimination in the toilet at 150%. The IRD for independent requests was small at -42%, small for a reduction in wet pants at -33.3%, and small for elimination in the toilet at 29.8%.

Awareness Training Discussion

The purpose of this study was to examine the implementation of an awareness training procedure alone to increase requests for and voids in the toilet. Intervention included pre-scheduled sittings on the toilet along with reinforcement for requests to use the toilet, dry pants, and eliminations in the toilet. As a result, Calvin learned to independently eliminate in the toilet.

To meet the criteria for awareness training requires verbal or non-verbal identification of antecedent trigger behaviors [1]. Identification is typically some physical behavior. The awareness training procedure for toilet training focused specifically on the private physiological drive to urinate and defecate. The overt indicators of the physiological drive to eliminate were both verbal requesting to go to the bathroom and elimination in the toilet. Following scheduled training to detect the physiological drive paired with training to request to use the bathroom, elimination in the toilet increased while the rate of wet pants decreased.

Statistically, while the IRD was insignificant for all three dependent measures, MBR was moderate for reducing wet pants and significant for elimination in the toilet. Additionally, PND, which is the most commonly reported single-subject effect size, was moderate for independent requests and highly significant for both reducing wet pants and eliminating in the toilet.

Comparing evaluations of all three effect size measures, improvement in voiding in the toilet was significant with reducing wet pants as moderately significant, and requesting as primarily insignificant. It is important to note that these effect sizes are meant to supplement visual analysis only and should not be the primary means of interpreting single-case research outcomes [26]. These effect sizes can be useful in making inferences when visual analysis is not clear, increased precision in detecting smaller effect sizes commonly reported in single-subject research, increased confidence results were not solely due to chance, and are important for future replication and meta- analyses to further establish awareness training as an evidence-based intervention. However, non- regression measures of effect size are not without their limitations. In particular, measures, such as PND have been found to be sensitive to outlying data points and the number of data points in a intervention phase in addition to decreased sensitivity to other outcome indices such as trend data [27].

The greatest discrepancy in analysis was found with the percent of independent requests. Specifically, requests did increase, noting both trend analysis and the small effect sizes, but not as expected on the surface. While the small average percentage increase in independent requests does correspond to the small effect sizes reported, this numerical data does not fully account for the behaviour of requesting which is dependent on the physiological drive to eliminate. In this way, the overall reduction in wet pants along with the overall increase in requests shows that verbal requests may have served in some capacity as an indicator of private awareness. For example, about 89% of all sessions with requests also ended with Calvin remaining dry the entire session. Furthermore, 85% of all sessions without requests also ended with Calvin remaining dry the entire session. Therefore, when requests did not occur, 85% of the time Calvin did not have to eliminate, further indicating awareness of the private physiological drive to eliminate.

These findings concur with the findings from Marcus, et al. [28]. In their study of children with autism, awareness training was combined with Gait spot auditory speakers to reduce toe walking across three, young boys by 77% or more. The speakers were added as an additional auditory stimulus for response detection and as a prompt for the competing response.

While awareness training was successful in reducing incidents of wet pants and increasing both independent requests to eliminate and eliminations in the toilet, intervention was not without its limitations. First, the overall data sets for wet pants and elimination in the toilet were quite unstable in data at intervention outset, noting downward trending data for wet pants and upward trending data for elimination in the toilet. As a general rule in evaluating single-subject research, three stable points of data, or a steady state of data, are needed before intervening [29]. Increased rates of responding are most likely due to the immediacy of the implemented intervention, noting that a formal baseline phase was not conducted. Therefore, it cannot be stated with full certainty if Calvin's voiding increased beyond pre-intervention nor if his pants wetting reduced below pre-intervention levels.

A second limitation was noted in the independent requesting data. Visual analysis indicates large ranges in variability between data points. Greater variability in the data from the trend line is generally indicative of threats to stimulus control [29]. However, the fact remains that the threat to stimulus control may most likely have been both the private drive and motivating operation and the proper antecedent conditions to request to use the bathroom. This is more so a flaw in the data collection than a threat to the intervention where, if Calvin's motivation to eliminate was not substantial enough to evoke the verbal mand, then it is reasonable to expect that the verbal mand would not be observed. Further evidence for this point is noted in that, when requesting was made in each of 98 sessions, independent requesting was observed in all of these sessions while additionally noting that the average rate of wet pants declined from Phase 1 through Phase 15.

The third limitation to this intervention was the small sample data sets in Phases 1 through 13. Data points within these phases ranged from two to four points total, resulting in percentage data that widely varied based on the small sample size in each phase. Additionally, the single-subject effect sizes may not be sensitive to these small sample sizes (e.g., 150% for voids).

Further study in awareness training may be better supported by analyzing the physiological changes in the body that can be detected indicating a need to urinate or defecate (e.g. contraction of sphincter muscles) to provide further support for intervention findings. For instance, a body of research on bio-feedback shows its effectiveness for a variety of issues including fecal and urine elimination in addition to anxiety, attention-deficit hyperactivity disorder, headaches, hypertension, and temporomandibular disorder [30]. Bio-feedback specifically implores instrumentation to measure physiological behaviours in the body providing information on changing private states such as skin conductance, muscle contraction, or heart rate.

In particular, further demonstration of the awareness-based procedure in a multiple baseline across participants design can provide more compelling evidence of the intervention effect. In spite of these limitations, awareness training alone can produce significant results with respect to the acquisition of complex behaviour such as requesting and voiding in the toilet. These findings assist in demonstrating the awareness training component of HRT on its own and its impact on behaviour with a person with autism. Notably, awareness training can be helpful to increase desired and reduce undesired restricted and repetitive behaviours but with limitations that require the additional support of the other primary steps in HRT such as competing response training. The next study explored the second main component in HRT: Competing response training.

Component Study 2: Competing Response Training

Competing Response Operational Definition

Competing response training is the part of HRT that teaches the participant to perform a behaviour that is topographically incompatible with the target behavior [1]. Competing responses should be selected that can be performed for more than a minute, are socially inconspicuous, and are incompatible with the target behaviour.

Competing Response Participant

The file review identified one participant who had received Competing Response Training without the remainder of the whole HRT procedure. Tammy was a seven-year-old female who attended the clinic's ABA Intervention Center for autism spectrum disorder. She received intervention for 15 hours per week. She also attended part-time school at a local public school in the afternoon. On her last VB-MAPP Assessment before intervention Tammy was reported to have scored a total of 139 of 170 possible points. She could mand for a variety of different items whether present or not present and acquired new mands without formal training. She also demonstrated at least 15 spontaneous mands. Tammy tacted at least 200 different items or actions, with tacts generalizing across different examples of items. Tacts did include noun/verb combinations in addition to tacting adjectives and possessives. Echoic skills were mastered with Tammy scoring at least 90 on the EESA. With respect to social skills, Tammy primarily played by herself and displayed low interest toward peers. Of significant concern was reported immediate and delayed echolalia, specifically repeating parts of songs and television shows she had seen repeatedly throughout the day. This behaviour interfered with acquisition of new skills and was requested, by her parents, to address in therapy.

Target Behaviour Operational Definition

Vocal-verbal tics included delayed scripting from songs, television shows, or from previous intraverbal interactions out of context for the present intraverbal exchange. Examples included

singing songs following a mand or intraverbal statement from another person or delayed echolalia of verbal reprimands out of context for the intraverbal exchange (e.g., "stop that", "I told you that's not a toy", "that's not yours"), vocal stereotypy (e.g. "digga-digga-digga"), or clenching her teeth and drawing in air and saliva through her teeth. Non-examples included listener responses in context of the manded information, mands for items or activities, and verbal approximations of songs sang in a group, as part of an activity, or singing along with a recording of the same song.

Competing Response Procedure

Observation and intervention were implemented during Tammy's regular ABA therapy between 9 AM and 4 PM with an hour break in therapy from 12 PM to 1 PM for lunch. Sessions specifically were divided into two, three-hour blocks per day (from 9 AM to 12 PM and then again from 1 PM to 4 PM). All ABA therapy programs were implemented as indicated in her ABA intervention plan.

Upon observation of target behaviour, Tammy's therapist began to deliver high probability verbal and motor listener discrimination (LD) tasks. Tasks introduced required an echoic response ("say dog."), listener response (tacting picture cards, performing an action, or other listener task), motor imitation (clapping, waving, high-five, or other motor task), or intraverbal response (answering a question). Each LD task was followed by brief social praise ("that's right.") delivered in a positive tone of voice. The next task was then presented with a zero second delay following the brief social praise.

Delivery of both the LD task and brief social praise continued until Tammy responded to three- consecutive LD tasks in the absence of the target behaviour. At this point, the therapist discontinued the LD tasks until the next target behaviour was observed.

Data were retrieved, measuring the percentage of the session spent engaged in target behaviour. Data were collected on the data sheet in Appendix 2. Each time Tammy entered a new setting for therapy, a timer was started to record the duration she was in that setting. Setting was pre- defined as one of the following places in the clinic including Classroom 1, 2, or 3, gross motor gym, hallways, or life skills apartment kitchen. A second timer was used to collect the amount of time Tammy spent engaging in the target behaviour. Percentage of session spent engaged in target behaviour was calculated using the following formula:

$$\text{Percentage of Vocal-Verbal Tics} = \left(\frac{\text{Total Vocal-Verbal Tic Time in Seconds}}{\text{Total Intervention Time in Seconds}} \right) \text{X}100$$

Further data analysis was completed using single-subject design effect size measures including the Percentage of Non-Overlapping Data Points (PND), Mean Baseline Reduction (MBR), and Improved Rate Difference (IRD). PND [24] was calculated using the following formula:

$$\text{PND} = \frac{\text{\# Data Points below the Lowest Baseline Data Point}}{\text{\# Data Points in the Phase}}$$

Interpretation of the PND was completed with less than 50% concluding the intervention was ineffective, 50%-74% equating to inconclusive results, 75%-90% equating to an effective intervention, and greater than 90% equating to a highly effective intervention.

The MBR was calculated using the following formula:

$$\text{MBR} = \left(\frac{\text{Intervention Phase Mean} - \text{Baseline Phase Mean}}{\text{Baseline Phase Mean}} \right) \text{X}100$$

The MBR was interpreted where less than or equal to 50% was considered a low effect, 51%-74% was considered a medium effect, and greater than 75% was considered a high effect.

The IRD [26] was calculated using the following formula:

IRD = b – a, where;

a = data points in baseline that were less than or equal to exceeding any data point in intervention as an Improved Ratio (IR):

$$\text{IR} = \frac{\text{\# Improved Data Points in Baseline}}{\text{\# Total Baseline Data Points}}$$

b = data points in intervention that were less than all data points in baseline as an IR:

$$\text{IR} = \frac{\text{\# Non-Improved Data Points in Intervention}}{\text{\# Total Intervention Data Points}}$$

IRD was interpreted where effects scores of +/-0.50 were small and unreliable, scores between

+/-0.50 and +/-0.70 were moderate and somewhat meaningful, and scores above +/-0.70 were considered very large and significant.

Intervention was discontinued when the target behaviour dropped to 5% or less for ten consecutive sessions. Maintenance data were collected daily without intervention. Intervention procedures were re-instituted when maintenance data results showed four consecutive sessions above 5% target behaviour.

Competing Response Results

The percentage of vocal-verbal scripts per session is shown in Figure 5. Baseline data were collected across eight sessions of observation. The mean percentage of sessions with scripting were

51% (SD = 6%, range = 41% - 62%). Trend analysis of baseline data indicated a slight upward trend with the slope equal to 0.39% (variance = +/-10.62).

Intervention began at Session 9 and continued for 156 sessions with a mean percentage of sessions with scripting equal to 14% (SD = 12%, range = 1% - 58%). Across intervention sessions, data trended downward with a slope of -0.21% (variance = +/- 29.04). The PND fell in the very effective range at 97%. The MBR fell in the medium range at -73% and the IRD fell in the very effective range at 85%.

Following completion of the intervention phase, intervention was maintained starting at Session 167 and continued for 18 sessions. The mean percentage of sessions with vocal-verbal tics was 4% (SD = 3%, range = 1% - 13%). In maintenance, data trended upward at 0.27% (variance = +/- .0805). In terms of effect sizes, compared to baseline, the PND fell in the very effective range at 100%. The MBR fell in the high range at -91% and the IRD fell in the very effective range at 100%.

In spite of the significant reduction in vocal-verbal scripting, intervention was re-introduced at Session 186 for another 41 sessions. The mean percentage of sessions with vocal-verbal tics was 10% across the phase (SD = 5%, range = 3% - 21%). Trend data indicated an increase in behaviour at a rate of 0.03% (variance = +/- 0.116). In terms of effect sizes, compared to baseline, the PND fell in the very effective range at 100%. The MBR fell in the high range at -80% and the IRD fell in the very effective range at 100%.

At Session 228, the mastery criteria were increased and data collected for 23 sessions. The mean percentage of vocal-verbal tics was 8% (SD = 5%, range = 1% - 21%). Visual analysis of the intervention re-introduction phase shows the slope of the trend data to decline at a rate of -0.43% (variance = +/- 0.0712). The effect size during the intervention re-introduction phase, compared to baseline, showed the PND to fall in the very effective range at 100%. The MBR fell in the high range at -84% and the IRD fell in the very effective range at 100%.

Lastly, following the increased mastery criteria for intervention, maintenance was re-instituted at Session 252 and continued for 19 sessions. The mean percentage of vocal-verbal tics was 2% (SD = 1%, range = 0% - 5%). Trend analysis of the re-instituted maintenance phase showed percentage of vocal-verbal tics to decline by -0.08% (variance = +/-0.042). Effect sizes, were calculated compared to initial baseline. For the PND, results fell in the very effective range at 100%. The MBR fell in the high range at -95% and the IRD fell in the very effective range at 100%.

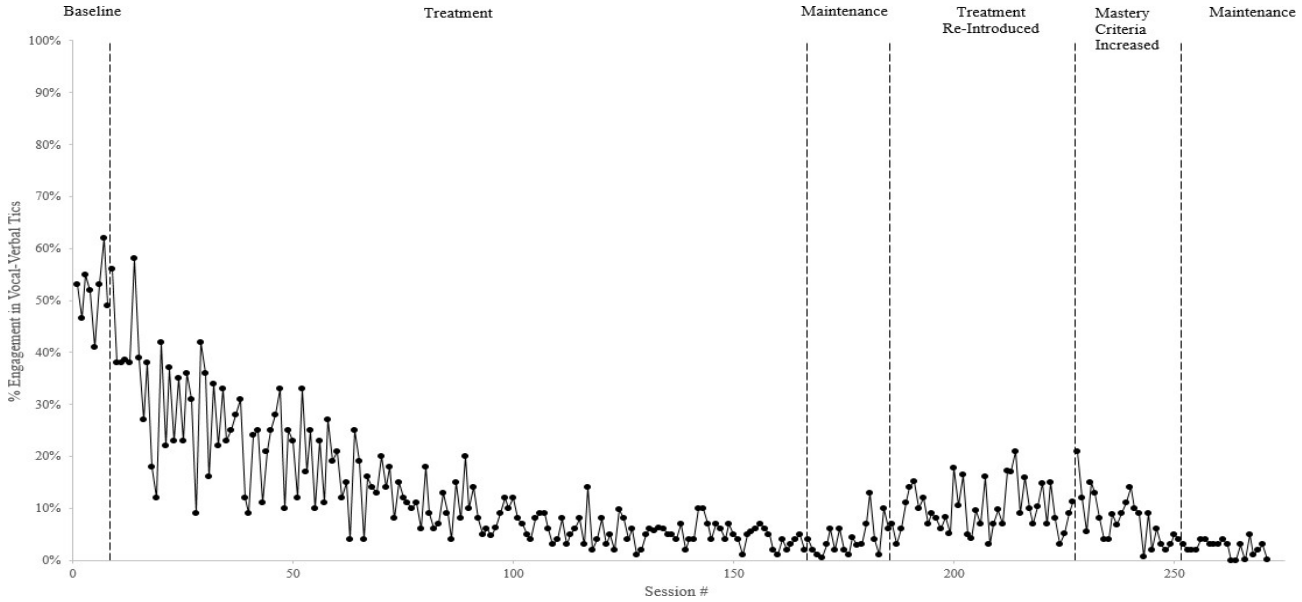

Figure 5: Percentage of verbal scripts emitted per session.

Competing Response Discussion

The purpose of this intervention was to introduce a competing response for vocal-verbal scripts to reduce their occurrence. Tammy's vocal-verbal tics were followed by implementation of high probability LD tasks until she answered correctly three consecutive times. As a result of this intervention, Tammy's vocal-verbal tics significantly reduced below baseline, demonstrating the use of a competing

response as a behaviour reduction technique. By definition, a competing response should interfere with the target behaviour, be capable of being performed for more than a minute, be socially inconspicuous, and be incompatible with the target behaviour. The questions asked contingent upon vocal-verbal scripts interfered with the vocal-verbal scripts as evidenced by the overall decline of the intervention data. The questions could also continue for a minute or more with the duration of questioning contingent upon accurate responding by Tammy. Social inconspicuousness of a behaviour, while observable, is subject to interpretation. The use of intraverbal language in a question-and-answer format, where the answers given by Tammy logically follows from the question asked, would be inconspicuous compared to unprovoked verbal behaviour that is unrelated to the current environmental context. The quick presentation of the questions to Tammy may not be as inconspicuous when compared to intraverbal conversation between two typically developed seven-year-old children.

However, since the questions significantly slowed the rate of vocal-verbal scripting, it would also follow that the rate of questioning too would have been expected to decrease. With this in mind, since the questioning occurred only briefly, it is concluded that the questioning was itself inconspicuous when compared to vocal-verbal scripting left without intervention. Lastly, Tammy could not script and speak a response to one of the questions at the same time, meeting the interference criterion of a competing response.

In the data set for the competing response intervention, vocal-verbal scripting reduced by an average of 73% after initial intervention, by 92% following the first maintenance phase and by 96% following the second maintenance phase. By intervention conclusion, variance from the trend data decreased by 99.6%, indicating significant stimulus control within the intervention. Therefore, the introduction of a question procedure following vocal-verbal scripting was highly successful in reducing the occurrence of scripting behavior.

Intervention was limited by several factors. First was that maintenance was conducted daily. This raises questions about how the intervention was faded out and if vocal-verbal scripts returned following the maintenance phase, calling into question the generalizability of the intervention [31]. Just as important, daily maintenance without phasing out support raises questions on the applied dimensions of ABA if the intervention is truly socially acceptable when it requires daily monitoring and support. Further data would be needed as to the longevity of the reductions in vocal- verbal scripts following intervention.

Another important limitation here is that the competing response used in Tammy's intervention required social support of another individual to ask the questions. Overt behaviour did reduce suggesting that private detection resulted within Tammy from a learning history where vocal-verbal scripting was immediately followed with the questioning contingency. With the available data however, it is not well-understood what, if any private behaviour changes did occur and further study would be needed to better understand any emerged or changed specific private behaviours. This limitation does help support the argument for the need for social support when implementing a competing response procedure for individuals with autism spectrum disorders. Perhaps an important modification for HRT in general when treating individuals with autism and other developmental disabilities is a more fluid transition between the major components with greater "overlap" of procedures when transitioning from one component to the next. For example, in the first component study, awareness training also required social support.

Lastly, the use of effect sizes in single-subject research is somewhat controversial. Non-regression effect sizes typically agree with visual inspection, reduce bias with small data sets, and are more efficient to calculate while regression effect sizes can be modeled before evaluating a intervention's effectiveness and can also be used to model changes in trend data's slope and y-intercept. Regardless, the three different non-regression models used agreed at interpretation in 14 of 15 possible comparisons in demonstration of validity between PND, MBR, and IRD.

In spite of these limitations, competing response training can be helpful in reducing behaviours in an individual with autism. As was noted with awareness training, competing response training is effective in isolation and may be enhanced with the additional components in the HRT procedure.

Furthermore, to be effective, the competing response required support from another party to prompt the LD tasks. The next study therefore examined the third major component of HRT: social supports training.

Component Study 3: Social Supports Training

Social Supports Operational Definition

Social support is a component of HRT that was first operationalized by Azrin, et al. as the provision of intervention by significant others in order to strengthen motivation [1]. More specifically, social supports include providing favorable comments following attempted practice of HRT procedures, favorable comments following behaviour-free periods, verbal reminders of the HRT procedures and to perform HRT procedures contingent upon observation by the significant other of target behaviour, and collecting various forms of data from caregivers by therapists and providing on-going training in HRT procedures.

Social Supports Participants

The review of medical charts identified 24 participants who had received social support as part of their intervention at

the hospital. They ranged in age from 2-11 years, with a mean age of 5.4 years. Two participants were excluded from this analysis because they had only one set of assessment scores. Data were extracted from the medical charts of the remaining 22 participants, including 15 males (68% of the total number of participants charts reviewed) and seven females (32% of the total number of participants charts reviewed). The range of expressive communication across participants included 14 demonstrating verbal communication in single words to short phrases, four using electronic augmented communication systems and speaking in single words to short phrases, and four who were non-verbal and did not demonstrate use of any alternative communication system.

The participants' data spanned across four different criterion-referenced measures. For the VB- MAPP Milestones Assessment, a total of 20 (13 boys, 7 girls) participant scores were extracted. The mean age of those assessed on the Milestones Assessment was 5.35 years old (range = 3-11 years old). On the VB-MAPP Barrier Assessment, a total of 11 (8 boys, 3 girls) participant scores were extracted. The mean age of those assessed on the Barrier Assessment was 5.73 years old (range: 4-8 years old). Data for only two boys was extracted on the Essentials for Living Assessment, both with a mean age of 9 years old (range: 7-11 years old). On the Assessment of Basic Language and Learning Skills (ABLLS) assessment, data were extracted from one boy who was also scored on the ESL assessment. He was 11- years-old.

Social Supports Procedures

Data were extracted from each intervention encounter and recorded in an Excel spreadsheet. These data included caregiver training session number, the date of the caregiver training, the duration of caregiver training session, whether or not homework was assigned during the previous appointment and if it was completed (denoted by "yes" it was completed, "no" it was not completed, or "none assigned" if therapy homework was not given to caregivers), the first date ABA therapy started, the last date of ABA therapy (up to December 31st, 2020), assessment dates, VB-MAPP MA scores, and VB-MAPP BA scores (where available).

Extracted data recorded into a Microsoft Excel Spreadsheet were saved to a HIPPA Compliant Microsoft SharePoint cloud storage drive required by the hospital's IRB. From the extracted variables, calculations were performed accounting for COVID-19 closure between March 2020 and August 2020. Calculations included:

1. Trend analyses of raw data for participants reported VB-MAPP milestones and barrier scores along with the cumulative number of minutes of caregiver training received by the participant's families at the time of each score.

a. Trend lines were added to the graphed data for each participant reporting at least two milestones and two barrier scores. The formula for each trend line was displayed in 'y = mx +b' form where m = the slope or rate of change of the trend data.

2. The average number of minutes of caregiver training per month:

$$\text{Minutes per Month} = \frac{\text{The Total Number of Provided Minutes of Caregiver Training}}{\text{Total Number of Months Enrolled in Intervention}}$$

3. The percentage of sessions with caregiver homework completed:

$$\text{Percentage} = \left[\frac{\text{\# of Caregiver Training Sessions with Completed Homework}}{\text{The Total \# of Caregiver Sessions with Homework}}\right] * 100$$

4. The percentage of change in criterion referenced assessment scores was derived from the slope of the linear graphed data for each participant's criterion referenced assessment scores.

The percentage of change = The Slope of the Trend Line * 100

5. The percentage of change in the VB-MAPP Barrier Assessment scores was derived from the slope of the linear graphed data for each participant's Barrier Assessment data.

The percentage of change = The Slope of the Trend Line * 100

Social Supports Results

Figure 6 represents a scatter plot of every participant and their VB-MAPP milestones assessment scores reported during the time frame under study. A total of 22 participants' scores were reported noting that two of the 22 participants only reported one milestones score. Of the 20 participants who did report two or more milestones' scores, all 20 reported an overall upward trend in their milestones scores following an increase in the cumulative amount of caregiver training. Overall, time was positively correlated with milestones scores. When comparing all 20 rates of change for trend data, the tends varied between a rate of 2.4 scores per minute of training and 39.1 scores per minute of training.

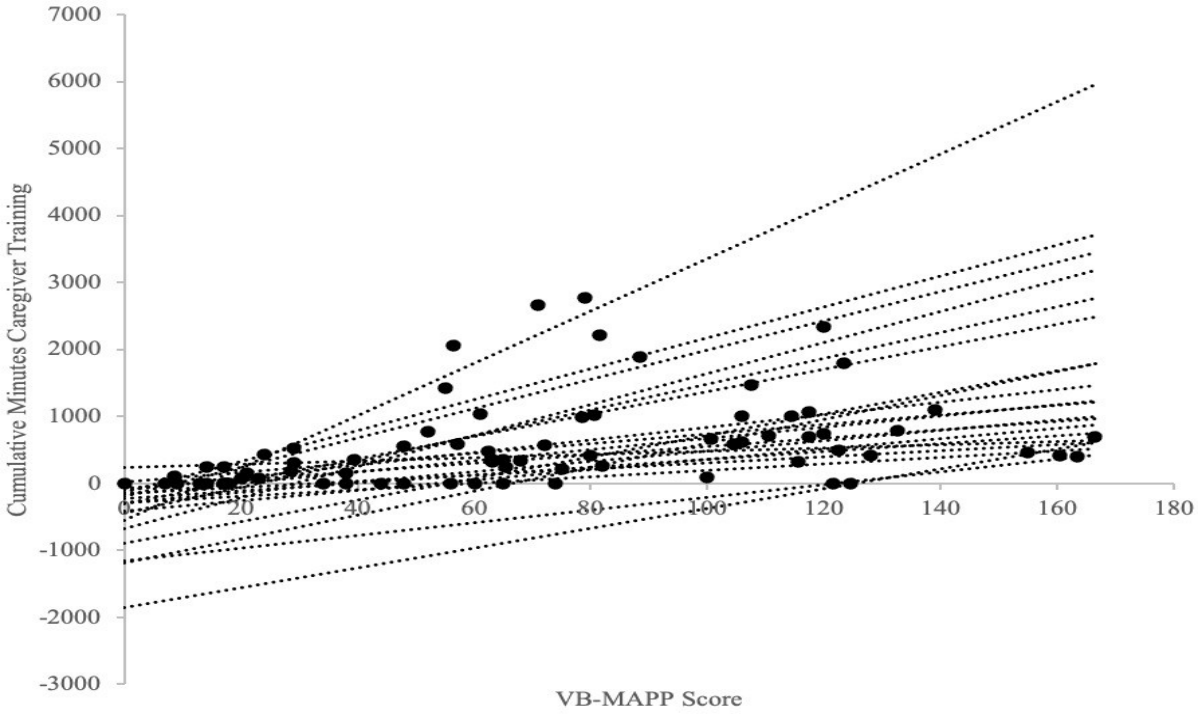

Figure 6: Raw data scatterplot of the cumulative number of minutes of caregiver training compared to VB-MAPP milestones scores.

Figure 7 represents a scatter plot of every participant and their VB-MAPP barrier scores reported during the time frame under study. A total of 17 participant's scores were reported noting that six of the 17 participants only reported one barrier score. Of the 11 participants who did report two or more barrier' scores, trends for eight participant's barrier scores decreased following an increase in the cumulative amount of caregiver training. The remaining three participant's barrier scores increased with more caregiver training. Comparing rates of change for the trend data, trends varied between a rate of 30 scores per minute of training and -72 scores per minute of training.

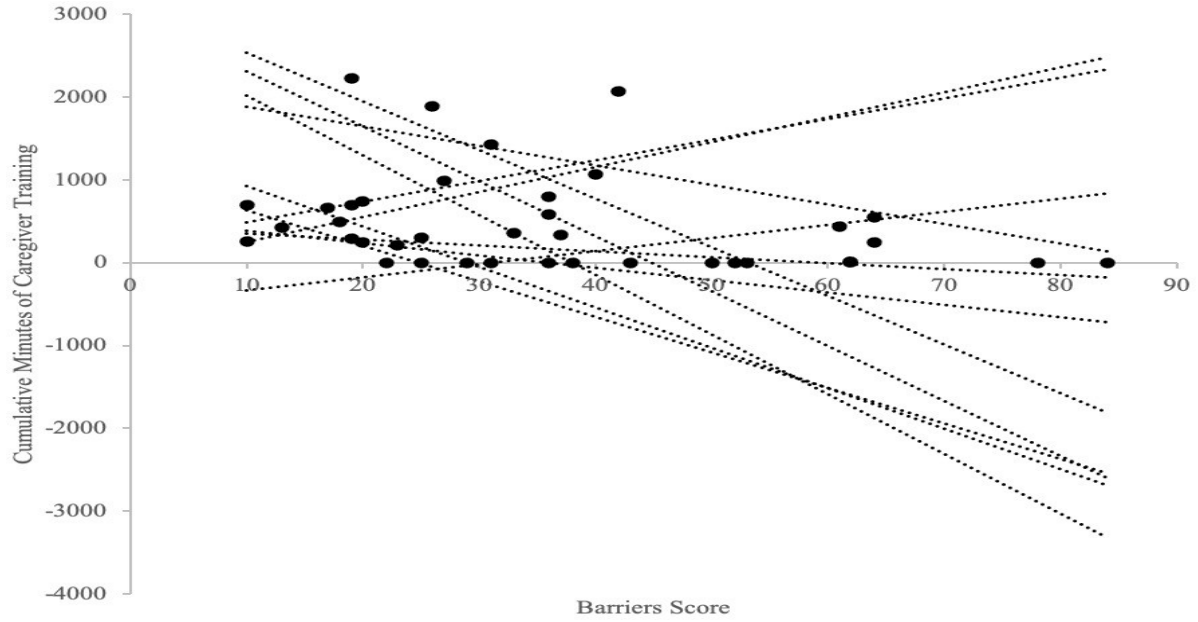

Figure 7: Raw data scatterplot of the cumulative number of minutes of caregiver training compared to barrier assessment scores.

Figure 8 shows the percentage of change from the first to the last reported criterion referenced assessment scores on the x-axis and the minutes of caregiver training delivered per month on the y-axis. Table 3 provides a numerical representation of the number of data points residing within the specified quadrants of the graph. When a minimum of 30-minutes per month of caregiver training and no change in assessment score were set as cutoffs, one data point fell below 30 minutes and 0% and none fell below 30-minutes and above 0%. When 30-minutes of caregiver training per month and 5% were used as cutoff scores, one data point fell below 30 minutes and 5% and none below 30- minutes and above 5%. For below 30-minutes of caregiver training per month and 10% as cutoff scores, one data point fell below 10% and none above.

Examining data points above 30-minutes of caregiver training per month and less than 0% cutoffs returned one data point below 0% and 21 data points above 0%. At a 5% cutoff, five data points fell below 5% and 17 above 5%. At a 10% cutoff, 11 fell below and 11 above the 10% cutoff.

When below 60-minutes of caregiver training per month and 0% were used as cutoff scores, two data points fell below 0% and six above 0%. At 5%, three points fell below 5% and 5 placed above. At 10%, five points placed below and three placed above.

Lastly, when above 60-minutes of caregiver training per month and 0% were used as cutoff scores, no points placed below 0% while 15 placed above 0%. At above 60-minutes of caregiver training per month and 5% were used as cutoff scores, three points placed below 5% while 12 placed above 5%. When above 60-minutes of caregiver training per month and 10% were used as cutoff scores, seven placed below 10% while eight placed above 10%.

For the entire sample, the mean change in criterion referenced assessment score was 11.74% (standard deviation (SD) = 11.59, range = 0.16% - 23.33%). The mean number of minutes per month of caregiver training was 74.24 minutes per month (SD = 30.23, range = 44.01-104.47).

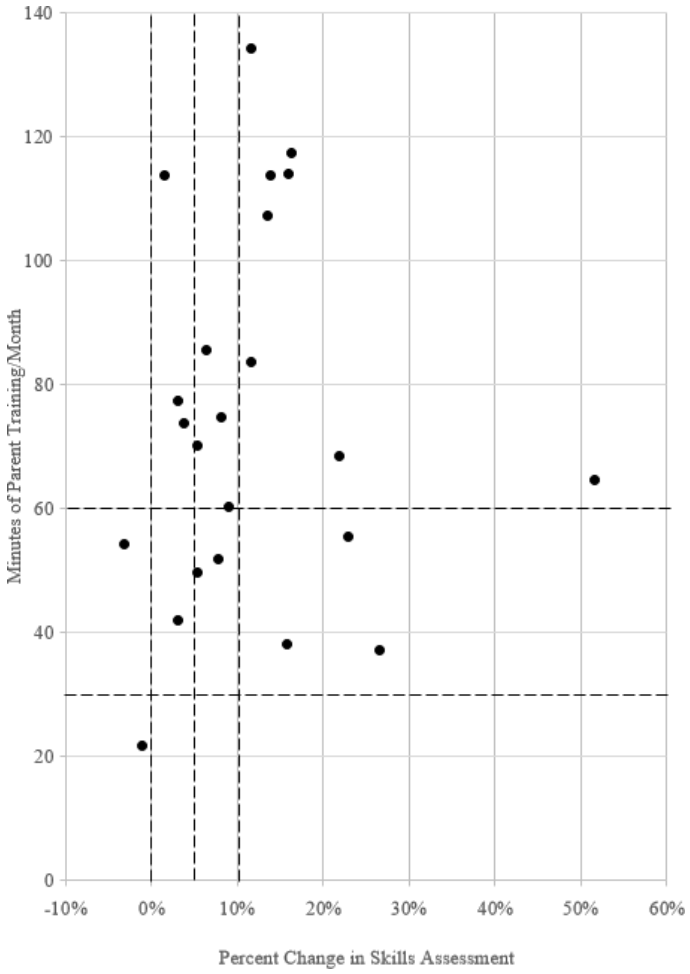

Figure 8: Scatter plot of percent change in skill assessment score and minutes of parent training per month.

		Minutes of Training Per Month			
		<30 min	>30 min	<60 min	>60 min
Percent Change in Skills Assessment	<0%	1	1	2	0
	>0%	0	21	6	15
	<5%	1	5	3	3
	>5%	0	17	5	12
	<10%	1	11	5	7
	>10%	0	11	3	8

Table 3: Numerical representation of the number of data points to place in each quadrant of Figure 6.

Figure 9 is a scatterplot of the percentage of change in criterion referenced assessment scores on the x-axis and the percentage of caregiver training homework completed from the previous training appointment on the y-axis. Table 4 provides a numerical representation of the number of data points residing within the specified quadrants of the graph. When less than 80% of caregiver training homework was completed, no one's assessment scores changed by less than 0%, six assessment scores increased above 0%, two increased by less than 5%, four increased over 5%, 4 increased less than 10%, and two increased over 10%. When more than 80% of caregiver training homework was completed, two overall decreased, 14 increased above 0%, four increased less than 5%, 12 increased over 5%, seven fell less than 10%, and nine increased above 10%.

When less than 90% of caregiver training homework was completed, no declines in assessment scores were reported, six increased above 0%, two fell between 0% and 5%, four increased above 5%, four fell between 5% and 10%, and two increased above 10%. When more than 90% of caregiver training homework was completed, two decreased in assessment scores, 14 increased above 0%, four scores fell below 5%, 12 scores increased above 5%, seven scored below 10%, and nine scores increased by more than 10%.

For the entire sample with reported homework and milestone change scores, mean homework completion was 84.59% (SD = 22.06, range = 38 – 100). The mean of assessment scores was 12.04% (SD

= 11.77%, range = -3.19% - 51.63%).

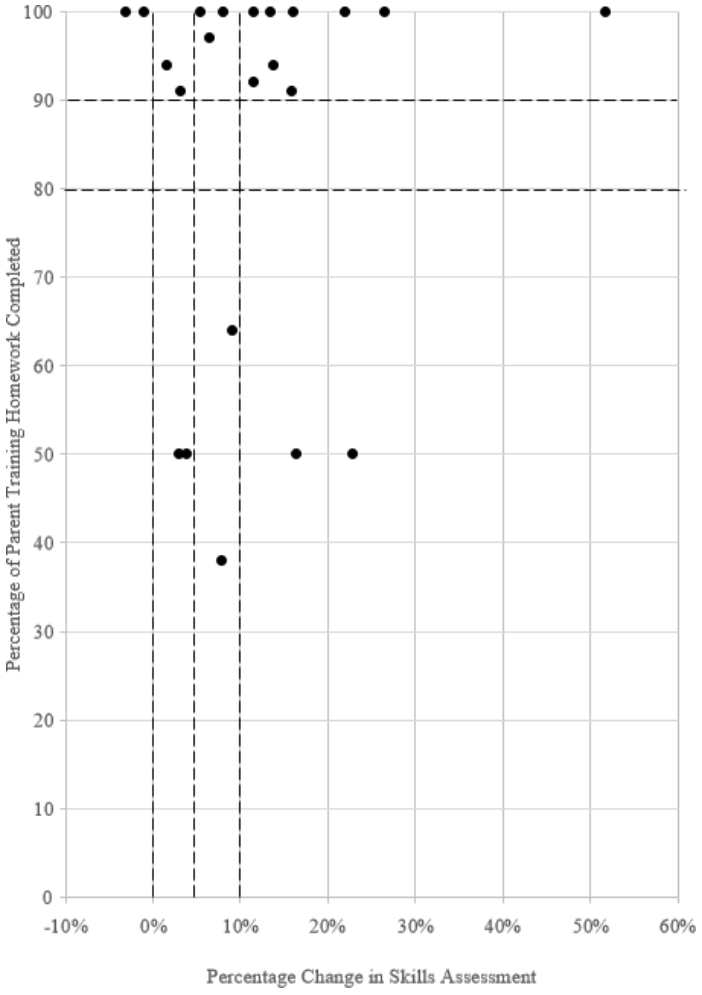

Figure 9: Scatter plot of percent change in skill assessment score and percentage of parent training homework completed.

		Percentage of Homework Completed			
		<80%	>80%	<90%	>90%
Percent Change in Skills Assessment	<0%	0	2	0	2
	>0%	6	14	6	14
	<5%	2	4	2	4
	>5%	4	12	4	12
	<10%	4	7	4	7
	>10%	2	9	2	9

Table 4: Numerical representation of the number of data points to place in each quadrant of Figure 7.

Figure 10 displays the changes in VB-MAPP Barrier Assessment scores based on the number of minutes of caregiver training received per month. The Table 5 provides a supplemental numerical count of the number of data points at each cutoff. When caregivers received less than 30 minutes of training per month, no changes in Barrier scores were observed at any of the percent change cutoff scores. When more than 30 minutes of caregiver training occurred per month, 4 participant's barrier scores increased above 0% while seven saw decreases below 0%. Six participant's barrier scores declined by less than 2% while five declined by more than 2%. Another nine declined by less than 4% while another two declined by more than 2%.

When 60 minutes of caregiver training per month was used as a cutoff score, three participant's scores increased above 0% in barrier while two decreased by more than 0%. Four participant's barrier scores changed by less than 2% and one reduced by more than 2%. When 4% change in barrier was used as a cutoff, four reduced by less than 4% and one participant reduced by more than 4%. With the cutoff above 60 minutes of training per month, one participant's barrier increased positively while five participant's barrier scores reduced by more than 0%. At a rate of change of 2%, two participant's reduced by less than 2% and four reduced barrier by more than 2%. Lastly, at a 4% not cutoff, five participant's reduced by less than 4% and one reduced by more than 4%.

Review of the overall sample averaged about 71.8 minutes per month of caregiver training (SD = 31.59, range = 37.17-134.07). Barrier scores of this sample averaged a reduction in barrier of -0.30% (SD = 5.09%, range = -8.70% - 9.65%).

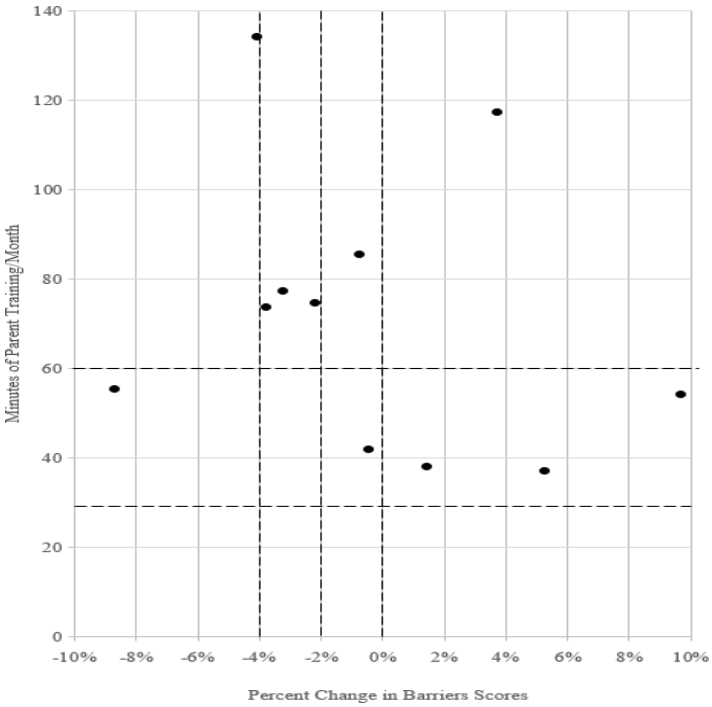

Figure 10: Scatter plot of percent change in barrier assessment score and minutes of parent training per month.

		Minutes of Training Per Month			
		<30 min	>30 min	<60 min	>60 min
Percent Change in Barrier Assessment	>0%	0	4	3	1
	<0%	0	7	2	5
	>-2%	0	6	4	2
	<-2%	0	5	1	4
	>-4%	0	9	4	5
	<-4%	0	2	1	1

Table 5: Numerical representation of the number of data points to place in each quadrant of Figure 8.

The final data set for caregiver training, comparing homework to changes in barrier scores is shown in Figure 9 with the frequency of data points within each cutoff criteria shown in table 6. When less than 80% of training homework was completed,

one participant's barrier score increased positively while three participant's barrier's scores declined. With a cutoff at -2% and less than 80% of homework completed, two participant's barrier scores decreased by less than 2% and two participant's barrier scores decreased by more than 2%. With a cutoff at -4% and less than 80% of homework completed, three participant's barrier scores decreased by less than 4% and one participant's barrier score decreased by more than 4%. Conversely, when more than 80% of training homework was completed at zero was the cutoff, three participant's barrier scores increased by more than 0% and four participants reduced barrier by more than 0%. At a -2% reduction, four participant's barrier reduced by less than the cutoff and three participant's barrier reduced by more than the cutoff. At -4% reduction, six participant's barrier reduced by less than the cutoff and one participant's barrier reduced by more than the cutoff.

Next, a 90% care giver training homework completion was used as a cutoff to analyze changes in barrier scores. When less than 90% of homework was completed, one participant's barrier score increased positively compared to three participant's barrier scores that reduced by more than 0%. Each of two participants' barrier scores changed by less than 2% and more than 2%. Less than a 4% change in barrier scores was noted for three participants while only one participant's barrier score decreased by more than 4%. In contrast, when more than 90% of homework was completed, three participant's barrier scores increased positively while four participants' barrier scores reduced by more than 0%. At a 2% cutoff, four participants' barrier scores reduced by less than 2% and three participants' barrier scores reduced by more than 4%.

The overall sample had a mean homework completion of 79.91% (SD = 23.94%, range = 50% - 100%). The barrier scores for the sample averaged -0.30% (SD = 5.09%, range = -8.70% - 9.65%).

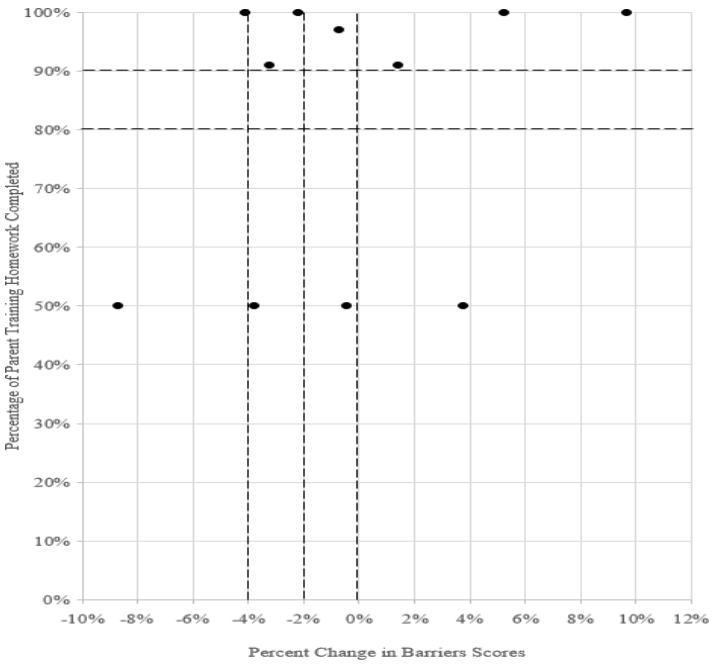

Figure 11: Scatter plot of percent change in barrier assessment score and percentage of parent training homework completed.

		Percentage of Homework Completed			
		<80%	>80%	<90%	>90%
Percent Change in Barrier Assessment	>0%	1	3	1	3
	<0%	3	4	3	4
	>-2%	2	4	2	4
	<-2%	2	3	2	3
	>-4%	3	6	3	6
	<-4%	1	1	1	1

Table 6: Numerical representation of the number of data points to place in each quadrant of Figure 9.

Social Supports Discussion

This social support study examined the longitudinal impact of caregiver support on the skill acquisition of 22 individuals and the reduction of treatment barriers of 11 individuals with autism. Data were gathered for participants over a three-year span with almost all participants increasing skills and decreasing barriers to treatment. The implementation of caregiver social supports in the course of ABA Therapy increased participants' motivation to acquire and demonstrate current skills as well as to learn new skills. Trend analysis of raw data shows participants milestones scores increasing by an average of 13.3 points following increases in caregiver training. Further analysis of the rate of change data showed 17 participants' milestones scores increased by more than 5% when more than 30 minutes of training was provided versus no participant increases over 5% with less than 30 minutes of training. When the criterion was increased to 60 minutes, 11 participants' milestones scores increased by more than 10% when more than 30 minutes of training was provided versus no participant score increases over 10% with less than 30 minutes of training. Criterion referenced scores increased by more than 5% for 12 participants receiving more than 60 minutes per month of training versus only five who increased with less than 60 minutes of training. Criterion referenced scores increased by more than 10% for eight participants receiving more than 60 minutes per month of training versus only three who received less than 60 minutes of training.

Participation in caregiver training homework further supported participant increases criterion referenced assessment scores. Criterion referenced scores increased by more than 5% for 12 participants when more than 80% of training homework was completed versus only four participants' caregivers who completed less than 80%. Scores increased by more than 10% for nine participants' caregivers completed more than 80% of training homework versus only two participants' caregivers who completed less than 80%. Similarly, when more than 90% of homework was completed, participants' skill assessment scores increased by more than 5% for 12 participants versus only four participants when less than 90% was completed. Participant skill assessment scores increased by more than 10% for nine participants whose caregivers completed more than 90% of training homework versus only two participants whose caregivers completed less than 90% of training homework.

Barrier scores mostly followed in suit, demonstrating an overall inverse relationship to milestones scores. Trend analysis of raw data shows participants barrier scores decreased by an average of 23.9 points following increases in caregiver training. Intervention barrier similarly reduced by two (5 at more than 30 minutes versus none at less than 30 minutes) and 4% (9 at more than 30 minutes versus none at less than 30 minutes) with more training. Training homework completion also reduced intervention barrier at two (3 at more than 80% of homework completion versus 2 at less than 80% homework completion) and 4% (6 at more than 80% of homework completion versus 3 at less than 80% homework completion).

As promising as these results are, they are not without their limitations. The specific means of involvement of caregivers was not clear from this retrospective data. What specifically was trained was not clearly defined in this retrospective study. Further information is needed to determine the specific training mechanisms used and those that are most effective in increasing intervention outcomes.

In spite of this unknown, the correlated relationship emphasizes the importance of caregiver involvement in training. Specifically, whatever interventions were provided, they were measurable in the sense that the increase in criterion referenced assessment scores was observed [31]. The interventions did produce a socially important effect as demonstrated by the data. Most importantly, the intervention addressed issues specifically for the participant that were socially important. This was beyond the scope of this study. Future research of specific caregiver training strategies and procedures would provide greater context to this data. How much quantifiable data were collected from caregivers is also unclear from these data in addition to the relatively limited study sample sizes.

In spite of these limitations, social support training for caregivers alone assisted in increasing desired skills and reducing barriers to treatment. However, these social support interventions would not be possible without additional components for caregivers to implement outside of direct training. This is the case in a HRT procedure where social support is combined with awareness training and competing response training to address a behaviour of interest.

General Discussion

The primary components encompassing an HRT intervention include awareness training, which can include describing and detecting a target behaviour, competing response training, and social supports training. While these interventions have been applied to neurotypical individuals, little research to date has explored the use of these procedures in individuals with autism.

A thorough file review was carried out of medical files held at a hospital in Michigan. All relevant files were reviewed between May 2017 and December 2020. Data were extracted from a total of 24 files. The first component study (n=1 participant) included awareness training whereby detection of the motivation to eliminate was indicated by a verbal mand to use the restroom along with dry pants and elimination in the toilet. While the mand data were not as clear given the motivation to request most likely varied across opportunities, mands did correlate very closely as training

progressed with elimination in the toilet. Furthermore, while the percentage of wet pants checks was relatively low to being with, a slight reduction in wet pants from the start of intervention was observed.

The second component study (n=1 participant) looked at the use of a competing response to reduce vocal-verbal scripting. From baseline to the first maintenance phase, vocal-verbal scripting reduced by an average of 47% and 49% at the second maintenance phase. Corresponding effect sizes were all consistent noting a significant reduction across all phases of intervention from baseline. Further data were not available following daily maintenance limiting the generalizability. Additionally, daily maintenance limited the application of the intervention, requiring direct support from another person on a daily basis. While the need for daily support was observed, it could be that the need for a support person underscores the importance of combining steps when using HRT with an individual with Autism.

The third component study (n=22 participants) examined the impact of social supports training on criterion-referenced assessment scores of individuals with autism. Results showed significant improvement in both increases in developmental skills and reduction in intervention barrier. Further conclusions were drawn in that, with at least an average of one hour per month of caregiver participation in intervention, milestones scores could increase by as much as 5-10% while barrier scores could reduce by as much as 2-4%. Raw data analysis further supported these improvements with all 20 participants milestones improving and eight of 11 reporting reductions when two or more barrier' scores were reported.

Despite the support for utilizing components of HRT to support individuals with autism, the current study has some apparent limitations. One of the key limitations is that the study did not include measures of treatment fidelity. For example, while the awareness training and competing response procedures primarily focused on their respective components, they did not explicitly rule out other procedures. In the awareness study, it was unclear if it was the only HRT procedure involved. It is possible that requesting to use the toilet also functioned as a competing response for wet pants. The somewhat unclear delineation between procedures was also observed in the competing response study, that may inherently have included social supports (through someone else asking the questions) and/or awareness training. Given that an awareness procedure required verbal or non-verbal identification of antecedent behaviour, the overall reduction in vocal stereotypy may indicate some private scripting.

In the social support study, the data showed a correlation between caregiver training and assessment scores, however it did not account for additional variables, such as the specific skills that were trained and the specific training methods that were used. The files also did not include any data regarding skills that may have been applied outside the intervention environment. Given the overall improvement it is entirely possible that caregivers applied their new skills outside intervention,

Another limitation of the current study is its reliance on data collected for clinical use, rather than for research purposes. While the use of these clinical data was fully approved by relevant ethics review boards, it is important to acknowledge the origin of the data and their retrospective use. Finally, the current analysis included only one participant in two of the studies. Further studies will be necessary to ensure that results are externally valid.

Following this component study of HRT, there are several other important areas for future research to explore. Future study should explore the fidelity with which components of HRT are implemented, starting with carefully defined target behaviour and clearly described procedures. The issues of whether or not awareness training and competing response training function as separate procedures or if these procedures are co-dependent also should be explore. A detailed exploration of the training methods and outcomes used in the social support component would help to ensure consistency across HRT studies.

In particular, the results reported here set the stage for more direct exploration of using the traditional components of awareness training, competing response training, and social support are sufficient to support individuals with autism who experience difficulties due to restricted and repetitive behaviours that are described in diagnostic manuals (DSM-5 and ICD-11). The potential effectiveness of these intervention raises essential ethical considerations surrounding intervention for restricted and repetitive behaviours. Of course, is it vitally important that individuals with autism play an active part in the decision of which behaviour are to be targeted for interventions [32], because some restricted and repetitive behaviours may help reduce physiological states of distress. On the other hand, it is acknowledged that restricted and repetitive behaviours can interfere with learning and may be socially stigmatizing. Another important consideration for future research is the conceptually systematic dimension of Applied Behaviour Analysis. In particular, similarities in interventions are derived from basic principles rather than as collections of tricks that become difficult to expand upon and teach and learn to and by others [31]. In other words, research should include specific exploration of HRT procedures as first defined in Azrin, et al. to better understand if the procedures alone are sufficient for individuals with autism or if modifications are needed [1]. In the meantime, the results of all three of the component analyses reported here provide strong evidence for the use of components of HRT in interventions aimed as supporting young people on the autism spectrum.

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