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Research Article

Interventions to Redirect Behaviors and Improve Learning in Non-Speaking Autistic Individuals: An Exploratory Analysis of the Rapid Prompting Method (RPM)

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ABSTRACT

The present study replicated and extended a relatively novel therapy for individuals with autism who lack functional speech, called Rapid Prompting Method (RPM). RPM uses rapid continuous prompting to redirect attention from sensory preoccupations to facilitate learning. It is known that many forms of assistive and augmentative communication such as RPM are deemed controversial based on reported lack of empirical evidence validating their effectiveness for improving learning and communication outcomes in non-speaking populations. The present study aims to assess the replicability of the Chen, et al., [1] outcomes and the potential of RPM as a form of support for nonspeaking autistic individuals.

The effects of RPM on attention, response accuracy and repetitive stereotypic behavior, were recorded and analyzed. The participants were 12 minimally verbal autistic individuals aged 8 to 37 years (M=20.08, SD=8.92).

The findings indicated that exposure to RPM increases accurate answers to questions and decreases repetitive behaviors. Although the increase in gaze behavior (indicative of attention) was not statistically significant, accurate answers increased significantly as attention increased. Exposure to the RPM appears to support a decrease in repetitive behaviors and an increase in correct responses to therapist's requests. RPM may help redirect attention from sensory preoccupations and suppress the effects of Repetitive and Stereotyped Behaviors (RSBs).

Key Words: Rapid prompting; Autism; Gaze behavior; Attention; Communication; Learning

INTRODUCTION

Autistic individuals present with any combination of verbal and non-verbal communication impairments. Verbal impairments may include lack of speech, limited speech (such as echolalia, monologues, neologism, narrow topics of interest) lack of reciprocal conversation and non-contextual speech. Non-verbal communication impairments refer to a limited ability to engage in or understand facial expressions, hand gestures, eye contact and gaze direction. In social contexts, individuals with autism struggle with coordinating their attention between multiple sensory modalities such as objects of common interest and other persons sharing that interest [1,2]. In addition, they often engage in extended parallel play in which they may play alongside other children but do not try to impact the others' game, rather than cooperative play [3]. These manifestations of restricted interest and social communication deficits are said to be a result of a limited ability to rapidly and flexibly synthesize multiple stimuli into coherent meaning [4,5]. It has been suggested that therapeutic methods using rapid rhythmic prompting can improve stimuli synthesis and cognition [6].

RPM is a therapeutic technique specifically created to improve learning and attention in non-speaking autistic persons. RPM uses a rhythmic prompting technique aimed, in part, at reducing Repetitive Stereotypic Behavior (RSB), such as hand flapping, as a component of an ongoing cycle of communication. By targeting RSBs and presenting prompts in a way that coincides with these repetitive behaviors, RPM shifts attention to the more salient prompts. Prompts are delivered in a rapid rhythmic manner designed to make them salient enough to displace any equally salient sensory preoccupation distracting the individual from the task at hand [7]. In so doing, RPM facilitates the completion of cognitive processes such as comprehension or response production. Rhythmic prompting techniques, such as those used in RPM, have also been used to increase cognitive control in individuals with neurodegenerative diseases who present with impairments in joint attention and motor initiation [8,9].

The RPM teacher or therapist has three major goals. One is to

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prevent calming behaviors from changing into arousing behaviors. The second goal is to use salient prompts to divert attention away from arousing behaviors. By delivering prompts in a rapid rhythmic manner, they become salient enough to challenge and displace arousing behaviors. The attentional demand and preoccupation of the arousing behavior inform the extent of competition needed by the teacher's prompt to challenge and displace the arousing behavior. This equation determines the pace of the prompting, such that the more salient the arousing (repetitive) behavior, the more rapid the prompt [10].

The third goal of RPM is to help learners move from concrete and direct responses to inferential and subjective opinions. RPM follows the Discrete Trial Training (DTT) method of using explicit instructions and reinforcement to create clear contingency situations that shape new skills. An example would be the teach-ask approach in which the teacher presents a short module, asks questions regarding the content presented and then reinforces. However, the method of reinforcement is such that RPM does not use extensive/effusive praise as reinforcement because it has the potential to arouse the autistic individual and hence inhibit learning. Further, RPM adheres to DTT's errorless learning format, which directs learners to the appropriate answer when they are unable to generate it on their own. The teacher waits for the learner and provides prompts to encourage them. Rather than providing negative feedback, the teacher rephrases or re-presents the request in a new way if the learner does not provide an accurate response at the end of the contingency situation. For example, the teacher may attempt to redirect or engage the student by writing out the question instead of speaking it [11]. Response verbalization is not a requirement and pointing is allowed in the communication process. Task complexity is increased gradually as therapy progresses. However, it is guided by the teacher's perception of the student's proficiency and proceeds in a step-by-step fashion with successive approximations.

Previous research indicates that intervention models specifically targeting the unique needs of nonspeaking autistic individuals and research examining such models are few [12]. Non-speaking autistic persons are often excluded from research on Autism Spectrum Disorder (ASD), further limiting the knowledge about this subpopulation and the repertoire of knowledge about ASD in general [13]. Many of the intervention models used for individuals on the more severe spectrum of autism are based on theories and results from research normed on the high-functioning subpopulation. It is unclear how much of these theories and results generalize to non-speaking autistic individuals. Thus, of primary interest here is the prior study by Chen, et al., [1] which focused on participants aged 8 to 14 years who had a clinical diagnosis of autism and lacked communicative speech. Chen, et al., [1] investigated the effects of RPM sessions on attention, RSBs, response accuracy and choice complexity. The nine participants attended five to eight 1-hour therapy sessions. The results revealed that exposure to RPM increased response accuracy and decreased RSBs. RSBs were also found to decrease as engaged attention increased, however, gaze behavior was not found to be indicative of attention and overtly engaged attention was negatively associated with response accuracy. More recent studies have questioned RPM's validity based on the authorship of messages produced by users and on the likelihood of prompt dependence. The purpose of the present study was to replicate, in part, Chen, et al., [1] and extend it by further examining how response accuracy and repetitive behavior are associated with the incident rates of prompting, the associations between RPM and joint attention and whether gaze behaviors, in their static and dynamic forms, were associated with response accuracy and RSB. This study was not intended to provide evidence of authorship on messages produced while using RPM.

MATERIALS AND METHODS

Participants

Twelve participants (M_{age}=20.08, SD_{age}=8.92) met the criteria for our study and were followed through an 8-session/participant summer camp at the Halo RPM Center in Austin, Texas. Eleven of the participants were males (91.67%) and one was female (8.33%). Two of the participants were identified as nonverbal by their parents (no speech at all-16.67%), six as minimally verbal (able to use few monologues and phrases, such as please, no, properly, etc.), three as mainly using scripted sentences/echolalia and one who could make simple reciprocal conversations. All participants had existing clinical diagnoses of ASD between ages 1 year 8 months and 3 years 6 months. Five participants had comorbid medical diagnoses, ranging from epilepsy (N=3), apraxia (N=1) and Attention Deficit Hyperactivity Disorder (ADHD) and deletion syndrome (N=1). All participants had a history of at least one other ASD intervention method including applied behavior analysis, speech therapy and/or occupational therapy. Seven were still receiving other forms of therapy at the time of our investigation. Seven participants identified as White, two as multiracial (white/Latino and white/Asian), two as Asian and one as Hispanic (8.33%).

Procedure

Our session procedures were approved by The University of Texas Permian Basin's Institutional Review Board. All parents confirmed they discussed the project with their participating child before signing the consent form. Each participant attended a total of 8 RPM sessions. The first session was a baseline assessment in which the therapist requested answers to questions ranging from 'Tell me about plants' to sentence completion requests or basic requests such as 'What letter/number is this?' Correct answers were rewarded with praise, while incorrect answers were redirected using rapidly presented correct oral options or a combination of orally presented answer options and a sequential pointing out of the spelled answer using a letter board. As participants' correct answers increased, requests were titrated higher to more complex questions. Requests mimicked repetitions using a strategic arrangement of keywords. For example, a sentence completion request may include 'The sun sits in the sky. In the day, the sun shines. At night, the sun fades. The earth travels around the ____?'

During each session, the coders annotated and coded behaviors indicative of attention such as when the participant looks at the therapist or the shared object while receiving an instruction (this behavior was coded as 1) or when the participant successfully alternated their gaze between the therapist and the shared object (this behavior was also coded as 1). Coders also annotated and coded behaviors indicative of repetitive and stereotypic behaviors (an example would be when the participant repeatedly flaps their hands) and learning, such as when the participant provides a correct answer to the therapist's request as described in the coding scheme.

Out of the eight RPM sessions, the first session was video recorded as baseline or time 1. The fourth was video recorded as midline

or time 2. The eighth video was then recorded as time 3. These three video-recorded sessions were subsequently coded to identify behaviors examined in our study. Video data for a session was about 30-45 minutes long. Behaviors were coded using a modified version of the attached coding scheme developed by Chen, et al., [1]. The coding scheme drew on items from the Autism Diagnostic Interview-Revised (ADIR), the Early Social Communication Scales (ESCS) and the Informative Pointing Method (IPM) manual [14,15]. Randomized session clips were coded using Datavyu video annotation software by two certified coders who were blind to serial order (session videos were randomized by giving them pseudo-chronological identities) [16]. Each videotaped session's middle interval of 10 minutes (e.g., the 11th to 20th minute of a 30-minute session) was coded. The session's middle interval was chosen to avoid any potential confounding associated with adjustment behaviors typical to the beginning of a new session and boredom and fatigue common in the second half of therapy sessions. Clips were coded continuously at 5-second intervals, allowing coders to concentrate on 5-second chunks at a time rather than a whole 10-minute interval at once. Four iterations were used to code the variables such as first, attention was coded; second, participant's behaviors including RSBs were coded; third therapists' prompts and fourth, response accuracy.

Community involvement statement

RPM providers were solely involved in the design and implementation of the intervention. These providers along with the families of the autistic individuals in their care were central to the dissemination of the baseline information, which encouraged community involvement both during and after the study.

Measures

The six behavior variables examined are listed below.

Gaze at therapist: Gaze at therapist was coded whenever the participant directed and sustained their gaze at the therapist for more than two seconds. A brief gaze of less than two seconds was not counted.

Gaze at shared object: Gaze at shared object was coded when the participant directed their gaze at the object of the therapist's instruction (e.g., the letter board, toy, paper, pencil, crayon, picture) for more than two seconds. A brief gaze of less than two seconds was not counted.

Joint attention: Joint attention was coded when the participant alternated their gaze between the therapist and the object of shared interest for more than two seconds. A brief gaze of less than two seconds was not counted.

Incidence rate of prompting: The incidence rate of prompting was coded as the number of times the therapist spoke to or touched the participant to redirect them to her initial request. Every word said after an initial request was counted as a verbal prompt, while every touch, except to give or retrieve a writing material, was counted as physical prompt. Each prompt was counted as one instance.

Repetitive Stereotypic Behavior (RSB): RSB was coded as every repetitive and irrelevant vocal sound (e.g., constant clearing of the throat, humming, echolalia), every repetitive object usage (e.g., consistently shoving items into the mouth) and every repetitive motor movement, including hand flapping, finger wiggling and jumping. Each RSB was counted as one instance.

Response accuracy: Every response accepted by the therapist was counted as one instance. Responses that were re-directed or led to the rephrasing of the initial request were not counted.

RESULTS

All 36 sessions (12 participants across times 1, 2 and 3 were coded by both coders and the interrater reliability was evaluated using Cohen's Kappa test of interrater reliability. Rating agreement between both coders ranged from 83% to 97%. Table 1 presents agreement values for the six behavior variables (Table 1).

Table 1: Interrater agreement measures.

Behavior variables	Kappa value	% agreement
Gaze at therapist	0.907	91%
Gaze at shared object	0.941	94%
Joint attention	0.825	83%
Prompting	0.971	97%
Repetitive behavior	0.971	97%
Response accuracy	0.97	97%

Descriptive statistics

Table 2 presents descriptive statistics for the six behaviors at each level of exposure to RPM, Time 1, Time 2 and Time 3. It was found that gaze directed at the therapist increased from 7 at Time 1 (M=7.00, SD=11.35) to 11.08 at Time 2 (M=11.08, SD=13.85) and then decreased to 8.67 at Time 3 (M=8.67, SD=7.32) (Table 2).

Table 2: Descriptive statistics of Rapid Prompting Method (RPM) behavior variables.

Behavior variables	Time 1		Time 2		Time 3	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Gaze at therapist	7.0	11.35	11.08	13.85	8.67	7.32
Gaze at shared object	20.67	13.99	23.75	11.97	23.25	11.0
Joint attention	27.67	24.67	34.83	24.03	31.92	13.91
Prompting	59.08	45.62	30.67	23.78	18.33	20.72
Repetitive behavior	32.0	31.58	19.83	31.59	13.75	11.19
Response accuracy	18.17	10.44	28.67	13.48	35.5	17.85

Hypothesis 1: Ongoing exposure to RPM will increase attention

RPM's association with joint attention: Exposure to RPM sessions did not significantly increase clients' behaviors indicative of attention. The repeated measures one-way analysis of variance for joint attention from Time 1 (M=27.67, SD=24.67), to Time 2 (M=34.83, SD=24.03) and Time 3 (M=31.92, SD=13.91) showed that the mean differences were not statistically significant $F(2,22)=1.21$, $p>0.05$. The frequency of participants' joint attention behaviors did not significantly increase from the first time they were exposed to RPM through the eighth exposure.

RPM's association with gaze at therapist: The analysis of variance

for gaze at therapist Time 1 (M=7.00, SD=11.35), Time 2 (M=11.08, SD=13.85) and Time 3 (M=8.67, SD=7.32) also did not show statistical significance, F (1.89, 14.14)=0.71, p ≥ 0.05.

RPM's association with gaze at shared object: Mean differences of gaze at shared object from Time 1 (M=20.67, SD=13.99), Time 2 (M=23.75, SD=11.97), to Time 3 (M=23.25, SD=11.0), were not statistically significant F (2,22)=0.84, p>0.05. Hypothesis 1 was not confirmed.

Hypothesis 2: With increased attention, RSB will decrease and response accuracy will increase

RPM's association with RSB: Mean RSB from Time 1 (M=32.00, SD=31.59), Time 2 (M=19.83, SD=15.65) and Time 3 (M=13.75, SD=11.19) significantly differed from each other F (2,22)=5.79, p=0.009, η_p^2 =0.35. These results suggest that with continued exposure to RPM the incidents of participants' RSB decreased at an average rate of 12.17 and 6.08 respectively. A post hoc analysis using the Lysergic cid Diethylamide (LSD) test showed that RSB significantly decreased between Time 1 and Time 3 (M_{diff} =18.25, 95% CI (4.85, 36.64), p=0.01), but not between Time 1 and Time 2 (M_{diff}=12.17, 95% CI (-1.93, 26.26), p>0.05), nor between Time 2 and Time 3 (M_{diff}=6.08, 95% CI (-1.32, 13.49), p>0.05).

RPM's association with response accuracy: The mean differences in response accuracy from Time 1 (M=18.17, SD=10.44), Time 2 (M=28.67, SD=13.48), to Time 3 (M=35.5, SD=17.85) were statistically significant F (1.33,14.67)=15.17, p<0.001, η_p^2 =0.58, suggesting that as exposure to RPM progressed, participants' response accuracy increased. Post hoc analyses showed that response accuracy increased significantly between Time 1 and Time 2 (M_{diff} =-10.5, 95% CI (-16.85, -4.16), p=0.004), Time 1 and Time 3 (M_{diff}=-17.33, 95% CI (-26.38, -8.29), p<0.001) and Time 2 and Time 3 (M_{diff}=-6.83, 95% CI (-11.73, -1.94), p=0.01). Response accuracy thus increased with exposure to the therapy.

RPM's association with incident rates of prompting: A supplementary analysis of the effects of RPM on prompting showed that exposure to RPM sessions significantly decreased the incidence rates of prompting from Time 1 (M=59.08, SD=45.62), Time 2 (M=30.67, SD=23.78), to Time 3 (M=18.33, SD=20.72) if sphericity is assumed, F (2,22)=17.65, p<0.001, η_p^2 =0.62. Post hoc analyses showed that response accuracy increased significantly between Time 1 and Time 2 (M_{diff}=28.42, 95% CI (12.24, 44.59), p=0.003), Time 1 and Time 3 (M_{diff}= 40.75, 95% CI (21.6, 59.9), p<0.001) and Time 2 and Time 3 (M_{diff}=12.33, 95% CI (2.8, 21.86), p=0.02). Incidence rates of prompting increased across all levels of exposure to the therapy (Figure 1).

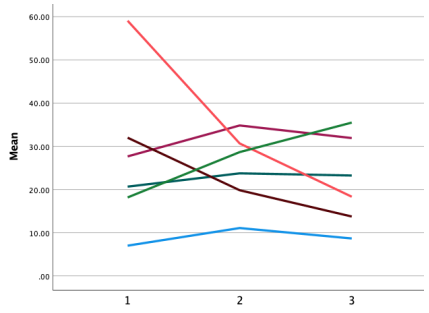

Figure 1: Graphical representation of the effects of Rapid Prompting Method (RPM) on gaze at therapist, gaze at shared object, joint attention, incidence rate of prompting, repetitive behavior and response accuracy. **Note:** (—): Gaze at therapist; (—): Gaze at shared object; (—): Joint attention; (—): Prompting; (—): Repetitive behaviour; (—): Response accuracy.

Hypotheses 3 and 4: Increase in response accuracy and decrease in RSB will be associated with prompting

RSB and response accuracy were included in this model as predictors of Incidence Rate of Prompting (IRP). It was expected that as RSB decreased and response accuracy increased, the incidence rate of prompting would decrease over time. However, response accuracy and RSB as a pair were not associated with decreases in the incidence rate of prompting at Time 1 R=41, R^2=16, F (2,9)=0.88, p=0.45 and Time 2 R=45, R^2=21, F (2,9)=1.16, p>0.05 nor did either contribute uniquely to the decrease of IRP over time. However, at Time 3, RSB and response accuracy as a pair showed a higher association with IRP than at Time 1 and Time 2, contributing about 43% of the differences in the rate of prompting. However, this association was not statistically significant R=65, R^2=43, F (2,9)=3.33, p>0.05. Nevertheless, when modeled alone, RSB contributed significantly to this difference (β=0.59, t=2.33, p=0.05). Therefore, lower levels of RSB were associated with lower incidence rates of prompting by Y=-11.42+1.1x at Time 3, suggesting that as RPM progressed, lower RSB correlated with lower incidence rate of prompting.

Hypothesis 5: Gaze at shared object will be associated with a higher rate of decrease in RSB and increase in response accuracy than will gaze at therapist and joint attention

To determine if joint attention predicted RSB and response accuracy and to further examine the assumption that autistic individuals may struggle to integrate multiple (visual and proprioceptive) sensory stimuli seen in therapists' movement, speech, facial expression, etc., *vs.* processing static visual stimulus seen in shared objects, multiple regression analyses were conducted. Here we examined how joint attention, gaze at therapist and gaze at object were associated with RSB and response accuracy at the three Time-sessions. The results showed that the three predictors as a set were not significantly related to RSB at Time 1 (R=0.39. R^2=0.15, F (2,9)=0.81, p>0.05), Time 2 (R=0.40, R^2=0.16, F (2,9)=0.88, p>0.05) or Time 3 (R=0.1, R^2=0.009, F (2,9)=0.04, >0.05). None of these variables made a unique contribution to RSB at any Time.

The three factors (gaze at therapist, gaze at shared object and joint attention) predicted response accuracy at Time 1 (R=0.94, R^2=0.88, F (2,9)=31.66, p<0.001) with gaze at shared object significantly contributing to the increase in response accuracy at this level (β=1.44, t=3.09, p=0.01). At Time 2, gaze at therapist and gaze at shared object worked together to predict response accuracy (R=0.73, R^2=0.53, F (2,9)=5.1, p<0.03), but separately, they were not predictors. At Time 3, all three variables as a set predicted response accuracy (R=0.81, R^2=0.65, F (2,9)=8.48, p<0.008), but only gaze at therapist (β=0.66, t=3.36, p=0.008) contributed significantly to the changes in response accuracy at Time 3.

Supplementary analysis: The moderating effects of age

The results of a split-plot analysis of variance revealed that age was not a factor in the effects of RPM on response accuracy, behaviors indicative of attention (gaze at therapist, gaze at shared object and joint attention) nor the incidence rate of prompting. However, age had a significant effect on RSB from Time 1 to Time 2 and Time 3, F (2,20)=9.07, p<0.002, η_p^2 =0.48. RSB significantly decreased from Time 1 (M=55.5, SD=29.01) to Time 2 (M=29.5, SD=14.64) and to Time 3 (M=20.83, SD=11.72) in child-autistic participants, but did not show a consistent downward trend from Time 1 (M=8.5, SD=5.28) to Time 2 (M=10.17, SD=10.03) and to Time 3

(M=6.67, SD=4.23) in adult-autistic participants.

DISCUSSION

We evaluated the effectiveness of RPM in improving indicators of learning such as attention and response accuracy as well as in improving behavioral outcomes by reducing RSBs. We found that RSB decreased as RPM sessions progressed. If RSBs fare sensory preoccupations developed by engaging the most salient sensory stimuli as coping mechanisms to reduce distractions at the sensorineural level, then it is possible that the technique of rapid prompting creates strong stimuli which compete with the sensory preoccupations inducing RSBs and displace them [17]. Rapid prompting may create familiarity and routine-like engagement that captures attention. This may explain the observed decreases in RSB found here. On the other hand, previous studies suggest that ritualistic behaviors tend to reduce anxiety in typically developing children and may serve the same function in autistic individuals [18,19]. Given that autistic individuals have been said to show normative attachment to familiar events, situations and people, another possible explanation for the decrease in RSB in this model may be that as sessions progressed, participants familiarized themselves with the therapist, the processes and the environment, thereby reducing the potential anxiety induced by unfamiliarity [20]. Finally, considering that response accuracy was low for most participants at baseline (Time 1), increasing accuracy as sessions progressed may have contributed to reduced anxiety and decreased RSB. Post hoc analyses showed that this decrease was significant over the longer period from Time 1 to Time 3 but not over the shorter periods from Time 1 to Time 2 and from Time 2 to Time 3. RPM may therefore be more effective at reducing RSBs in the long term.

Considering the effects of exposure to RPM on response accuracy, response accuracy was found to increase as RPM sessions progressed. Pairwise comparisons showed that this increase was significant over time. This suggests that RPM may support increased cognitive stimulation as it claims. RPM uses a languaging technique that communicates whole concepts to participants based on the principle that autistic individuals are capable of successfully completing complex tasks like typically developing individuals and have shown superior performance on tests of fluid intelligence and problem solving such as the Raven's progressive matrices [21]. The use of complex communication patterns in RPM reflects positive and high-performance expectations. Studies of positive expectations and performance in typically developing, as well as clinical populations, show that positive expectations lead to improved performance [22,23]. Studies have also revealed that the use of normal, regular speech in RPM, rather than the child-like speech format common with many ASD intervention models, reduces distraction and may be more indicative of attention and less sensory load [24,25].

Contrary to our first hypothesis and consistent with Chen, et al., [1], gaze behaviors indicative of attention did not increase over Time. This intervention model did not seem to be directly associated with attention. However, gaze behavior may not be the only indicator of engaged attention. RPM's framework of sitting side-by-side as opposed to the traditional face-to-face framework, may not facilitate gaze at therapist and thereby joint attention. Further, when we examined attentional variables (gaze at therapist, gaze at shared object and joint attention) as predictors of RSB and response accuracy, all three predictors were not associated with RSB. One possible explanation for this is that RPM considers calming RSBs as helpful components of the therapeutic process and uses them to harness attention rather than eliminate them. RPM builds learning content around individual participants' repetitive behaviors and restricted interests. In so doing, it is suggested that the attention given to the RSB is channeled into learning. Kryzak, et al., [26] indicated that teaching joint attention initiations with circumscribed interest-related materials benefits many children with ASD.

We found in the regression analyses for response accuracy that all three predictors as a set (gaze at therapist, gaze at shared object and joint attention) were positively related to response accuracy, such that as these behaviors increased as a set, the number of accurate responses given by participants increased simultaneously. This finding supports previous results indicating that attention (defined by gaze behavior) improves learning. Studies of typically developing as well as autistic individuals suggest that memory and successful retention depend heavily on attention [27]. Gaze at shared object and gaze on therapist made unique significant contributions to this relationship but joint attention did not. These results confirmed the hypothesis that gaze at shared object was more likely to contribute to increased response accuracy and decreased RSB than the other two attentional variables. Previous studies have shown that autistic persons perform equally well or even better when they rely solely on one sensory modality or when they can plan movements using static visual input rather than dynamic visual feedback required when alternating gaze [28,29].

Perhaps this is because persons with ASD do not integrate visual and proprioceptive inputs as efficiently or quickly as individuals who are not affected by autism [30]. Although there have been inconsistencies in the reports of the association between gaze and attention in ASD, indicating that gaze is not always indicative of attention, individuals with ASD may likely benefit from interventions designed to improve gaze behavior and attention [31].

RSB and response accuracy as a pair did not predict the incidence rate of prompting at any level of exposure to RPM. The pair however predicted about 42% of the decrease in prompting ($p=0.08$) and RSB made a significant contribution to this change. It is possible that as RSBs decrease over time, the need for prompting is reduced. The fading of prompting in this model may be indicative of improved behavioral control which has implications for improved social and cognitive outcomes. Prompt-fading techniques have been found to be successful in fostering the acquisition of behavior [32]. Here, RPM as a technique may facilitate the transfer of stimulus control. The transfer of stimulus control occurs when therapists gradually fade prompts until correct responses consistently occur under the appropriate stimulus control conditions.

The mean differences in attention, response accuracy and incidence rate of prompting for child-autistic participants *versus* adult-autistic participants were not significant. However, the difference between these two age groups was significant for repetitive behaviors. Child-autistic participants showed a significant decrease in RSB from Time 1 to Time 3, while adult-autistic participants did not. One factor here is that child-autistic participants recorded significantly higher numbers of RSBs at baseline (Time 1) and across the sessions while older participants had lower RSB scores at baseline. It is possible that as autistic individuals advance in age, they acquire more adaptable social skills due to longer exposure to therapy than they had as children. Previous studies show that chronological age moderates the expression and severity of RSB [33,34].

Limitations

Given a non-experimental design, this study cannot establish causal relationships. It is possible that other factors that were not examined contributed to the outcomes reported here, therefore future studies may explore using experimental designs to establish causal relationships. Further, a sample size of 12 may not be large enough to make concrete predictions about this intervention method, future studies may explore larger sample sizes to increase predictability. Although we controlled for the history of RPM exposure, functional language and individual differences in therapist, larger sample sizes may increase the chances of identifying other individualistic factors (such as comorbid diagnosis, Intelligence Quotient (IQ), presence or absence of psychotropic medication, socio-economic status, etc.,) that may further predict the outcomes of this intervention model and more specifically characterize the profile of individuals RPM may support more effectively. Last, although the inclusion of one facilitator helps maintain the study's internal validity, future studies can include other providers of RPM to investigate whether the skills are transferable and whether the outcomes of RPM are achievable by other facilitators in diverse clinical and educational settings. Future studies may explore the authorship of messages produced using RPM.

Implications for practice

The present study shows how RPM engages nonspeaking autistic individuals in a way that redirects behavior from sensory preoccupations to shared interests. These effects appear to arise as repetitive behaviors are replaced by prompted, directed behaviors. Non-speaking autistic people may benefit from RPM techniques to reduce RSBs that may interfere with learning. RPM may also be indicative of prompt fading as data from this study showed that the incident rates of prompting decreased concurrently with RSBs as exposure to RPM increased. Further, the present study also contributes to a clearer characterization of RPM techniques for ASD.

CONCLUSION

In summary, the results of the present study suggest that RPM may decrease the occurrence of RSB among autistic individuals who lack functional speech. Although this technique did not significantly improve attention, results showed that increases in attentional variables, especially gaze at shared object and gaze at therapist, corresponded with increases in response accuracy after just eight sessions. This technique may facilitate stimulus control indicating social-behavioral adaptation and cognitive improvement, especially with more sessions. Finally, while the incidence rate of prompting decreased over time, this decrease was not associated with response accuracy. This may be taken to indicate that even at a reduced rate of prompting, response accuracy was sustained. Response accuracy was not dependent on prompting. This may have implications for sustained learning, as learned materials did not decrease with decreasing prompting.

REFERENCES

1. Chen GM, Yoder KJ, Ganzel BL, Goodwin MS, Belmonte MK. Harnessing repetitive behaviours to engage attention and learning in a novel therapy for autism: an exploratory analysis. Front Psychol. 2012;3:12.
2. Mundy P, Gwaltney M, Henderson H. Self-referenced processing, neurodevelopment and joint attention in autism. Autism. 2010;14(5):408-429.
3. Belmonte MK, Baron-Cohen S. Normal sibs of children with autism share negative frontal but not positive sensory abnormalities: Preliminary evidence from fMRI during processing of visual distractors. InSoc Neurosci Abstr. 2004;30(582.10).
4. Belmonte MK, Allen G, Beckel-Mitchener A, Boulanger LM, Carper RA, Webb SJ. Autism and abnormal development of brain connectivity. J Neurosci. 2004;24(42):9228-9231.
5. Minshew NJ, Goldstein G, Siegel DJ. Neuropsychologic functioning in autism: Profile of a complex information processing disorder. J Int Neuropsychol Soc. 1997;3(4):303-316.
6. Mukhopadhyay S. Understanding autism through rapid prompting method. Outskirts Press. 2008.
7. Ochs E, Solomon O, Sterponi L. Limitations and transformations of habitus in child-directed communication. Discourse Stud. 2005;7(4-5):547-583.
8. Arias P, Cudeiro J. Effects of rhythmic sensory stimulation (auditory, visual) on gait in Parkinson's disease patients. Exp Brain Res. 2008;186(4):589-601.
9. Gernsbacher MA, Sauer EA, Geye HM, Schweigert EK, Hill Goldsmith H. Infant and toddler oral and manual motor skills predict later speech fluency in autism. J Child Psychol Psychiatry. 2008;49(1):43-50.
10. Iversen P. The informative pointing method. Unpublished. 2007;8(201):1.
11. Forsey J, Bird EK. Brief report: The effects of typed and spoken modality combinations on the language performance of adults with autism. J Autism Dev Disord. 1996;26(6):643-649.
12. McKinney A, Weisblatt EJ, Hotson KL, Bilal Ahmed Z, Dias C, BenShalom D, et al. Overcoming hurdles to intervention studies with autistic children with profound communication difficulties and their families. Autism. 2021;25(6):1627-1639.
13. Jack A, Pelphrey KA. Annual research review: Understudied populations within the autism spectrum-current trends and future directions in neuroimaging research. J Child Psychol Psychiatry. 2017;58(4):411-435.
14. Lord C, Risi S, Lambrecht L, Cook EH, Leventhal BL, DiLavore PC, et al. The Autism Diagnostic Observation Schedule-Generic: A standard measure of social and communication deficits associated with the spectrum of autism. J Autism Dev Disord. 2000;30(3):205-223.
15. Mundy P, Delgado C, Block J, Venezia M, Hogan A, Seibert J. Early Social Communication Scales (ESCS). Coral Gables. 2003.
16. Datavyu Team. Datavyu: A video coding tool. New York University. 2014.
17. Belmonte MK, Gomot M, Baron-Cohen S. Visual attention in autism families: Unaffected sibs share atypical frontal activation. J Child Psychol Psychiatry. 2010;51(3):259-276.
18. Evans DW, Leckman JF, Carter A, Reznick JS, Henshaw D, King RA, et al. Ritual, habit and perfectionism: The prevalence and development of compulsive-like behavior in normal young children. Child Dev. 1997;68(1):58-68.
19. Evans DW. Rituals, compulsions and other syncretic tools: Insights from Werner's comparative psychology. J Adult Dev. 2000;7(1):49-61.
20. Nuske HJ, Vivanti G, Dissanayake C. Reactivity to fearful expressions of familiar and unfamiliar people in children with autism: An eye-tracking pupillometry study. J Neurodev Disord. 2014;6(1):14.
21. Soulieres I, Dawson M, Samson F, Barbeau EB, Sahyoun CP, Strangman GE, et al. Enhanced visual processing contributes to matrix reasoning in autism. Hum Brain Mapp. 2009;30(12):4082-4107.
22. Alexander KL, Entwisle DR, Bedinger SD. When expectations work:

Race and socioeconomic differences in school performance. Soc Psychol Q. 1994;57(4):283-299.

23. Yamamoto Y, Holloway SD. Parental expectations and children's academic performance in sociocultural context. Educ Psychol Rev. 2010;22:189-214.
24. Akhtar N, Gernsbacher MA. On privileging the role of gaze in infant social cognition. Child Dev Perspect. 2008;2(2):59-65.
25. Akhtar N, Jaswal VK. Stretching the social: Broadening the behavioral indicators of sociality. Child Dev Perspect. 2020;14(1):28-33.
26. Kryzak LA, Jones EA. The effect of prompts within embedded circumscribed interests to teach initiating joint attention in children with autism spectrum disorders. J Dev Phys Disabil. 2015;27:265-284.
27. Niu Z, Zhong G, Yu H. A review on the attention mechanism of deep learning. Neurocomputing. 2021;452:48-62.
28. Baianu IC, Brown R, Glazebrook JF. A category theory and higher dimensional algebra approach to complex systems biology, meta-systems and ontological theory of levels: emergence of life, society, human consciousness and artificial intelligence. Acta Univers Apul. 2011(S1):176.
29. Haswell CC, Izawa J, Dowell LR, Mostofsky SH, Shadmehr R. Representation of internal models of action in the autistic brain. Nat Neurosci. 2009;12(8):970-972.
30. Bonneh YS, Belmonte MK, Pei F, Iversen PE, Kenet T, Akshoomoff N, et al. Cross-modal extinction in a boy with severely autistic behaviour and high verbal intelligence. Cogn Neuropsychol. 2008;25(5):635-652.
31. Kasari C, Paparella T, Freeman S, Jahromi LB. Language outcome in autism: randomized comparison of joint attention and play interventions. J Consult Clin Psychol. 2008;76(1):125-137.
32. Cengher M, Budd A, Farrell N, Fienup DM. A review of prompt-fading procedures: Implications for effective and efficient skill acquisition. J Dev Phys Disabil. 2018;30(2):155-173.
33. Boyd BA, McDonough SG, Bodfish JW. Evidence-based behavioral interventions for repetitive behaviors in autism. J Autism Dev Disord. 2012;42(6):1236-1248.
34. Bishop SL, Richler J, Lord C. Association between restricted and repetitive behaviors and nonverbal IQ in children with autism spectrum disorders. Child Neuropsychol. 2006;12(4-5):247-267.