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Increasing compliance of children with autism: Effects of programmed reinforcement for high-probability requests and varied inter-instruction intervals

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ABSTRACT

Research on the high-probability (high-*p*) request sequence shows that compliance with low-probability (low-*p*) requests generally increases when preceded by a series of high-*p* requests. Few studies have conducted formal preference assessments to identify the consequences used for compliance, which may partly explain treatment failures, and still fewer have examined the impact of programmed reinforcement for compliance to high-*p* requests. The present study first investigated the effects of high-*p* request sequences, with and without programmed reinforcement, on compliance to low-*p* requests using a reversal design with three children with autism. Preferred stimuli were identified via formal reinforcer preference assessments, and compliance, latency to compliance, and task completion time were measured. Results demonstrated high-*p* request sequences were most effective in increasing compliance and reducing compliance latency and task completion time when implemented with programmed reinforcement. Generalization probes conducted with a second trainer indicated that compliance occurred for all but one of the participants' low-*p* requests. The further effects of inter-instruction intervals (10 s and 5 s) were examined using a combined alternating treatments and reversal design with one participant. Results demonstrated high-*p* request sequences were most effective in increasing compliance when implemented with 5 s inter-instruction intervals and with programmed reinforcement.

1. Introduction

Children with autism spectrum disorders often have difficulty following requests or instructions. Within behavior analysis, basic research on behavioral momentum (Nevin, 1996) has lead to the development of an antecedent-based intervention for increasing compliance, called the high-probability request sequences (HPRS). Applied research on HPRS involves presenting a series of high-probability (high-*p*) requests that an individual has a history of compliance with prior to a low-probability (low-*p*) request that an individual has a history of noncompliance with (Nevin, 1996). Considerable evidence shows that compliance with low-*p* requests generally increases when preceded by a series of high-*p* requests (e.g., Jung, Sainato, & Davis, 2008; Mace et al., 1988; Mace, Mauro, Boyajian, & Eckert, 1997; Patel et al., 2006; Wehby & Hollahan, 2000). Antecedent-based interventions like the HPRS are generally more effective at increasing compliance compared to popular approaches to the treatment of child noncompliance, such as the delivery of rationales (Wilder, Allison, Nicholson,

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Abellon, & Saulnier, 2010) or giving advance notice of an upcoming instruction (Wilder, Nicholson, & Allison, 2010). However, despite the wealth of research demonstrating the effectiveness of the HPRS, treatment failures have been reported showing either no increases or very minor increases in compliance to low-*p* requests (e.g., Normand, Kestner, & Jessel, 2010; Rortvedt & Miltenberger, 1994; Zarcone, Iwata, Mazaleski, & Smith, 1994).

Zuluaga and Normand (2008) suggested that some treatment failures might be the result of the consequences for compliance with high-*p* requests not functioning as reinforcement. In the majority of studies, praise is the only consequence arranged for compliance with high-*p* requests (e.g., Austin & Agar, 2005; Rortvedt & Miltenberger, 1994; Zarcone et al., 1994), even though it is known that praise alone may be ineffective in increasing compliance to some low-*p* requests (Mace et al., 1997). Formal preference assessments to identify the consequences used for compliance have only rarely been conducted (e.g., Bullock & Normand, 2006; Zuluaga & Normand, 2008). For instance, Zuluaga and Normand (2008) first undertook a paired-stimulus preference assessment (Fisher et al., 1992) to identify preferred edible items, which was then followed by a brief multiple-stimulus-without-replacement assessment (Carr, Nicolson, & Higbee, 2000).

Having identified a range of preferred edible items that could be delivered promptly during sessions, Zuluaga and Normand (2008) measured compliance to low-*p* requests when programmed reinforcement followed compliance to high-*p* requests and when no programmed reinforcement followed compliance to high-*p* requests. Their findings showed that compliance with low-*p* requests only increased when high-*p* requests were followed with programmed reinforcement. Moreover, the findings from the formal preference assessments demonstrate convincingly that compliance with high-*p* and low-*p* requests occurred when the consequences delivered after compliance had been shown to actually function as reinforcement.

To date, several studies on the HPRS have employed a 10 s inter-instruction interval, which is defined as the time between the presentation of the last request and the presentation of the next request within the sequence (Bullock & Normand, 2006; Zuluaga & Normand, 2008). It is possible, however, that shorter inter-instruction intervals may be effective in increasing compliance, due to an increase in response rate and density of obtained reinforcement (Houlihan, Jacobson, & Brandon, 1994; Mace et al., 1988; Nevin, 1996). Houlihan et al. (1994), for instance, found that a HPRS with a 5 s inter-instruction interval resulted in higher rates of compliance compared to a 20 s interval. To the extent that compliance may persist when low-*p* requests are issued following short inter-instruction intervals such as 5 s, it remains to be seen whether the momentum of compliance occurs with or without the use of programmed reinforcement for the high-*p* requests.

The present study investigated the effects of implementing the HPRS with and without programmed reinforcement for high-*p* requests on compliance to low-*p* requests of three children with autism. Prior stimulus preference assessments determined the reinforcers to be used, and, with one participant, we assessed whether a shorter inter-instruction interval of 5 s would increase low-*p* compliance. In addition, we measured latency to, and duration of, compliance following high-*p* requests because decreased latency to compliance and task completion may permit increased presentation rates within sessions and facilitate subsequent skill acquisition (Houlihan et al., 1994; Mace et al., 1988; Wehby & Hollahan, 2000).

2. Methods

2.1. Participants and setting

Three children with a diagnosis of autism participated. Alan was 5 years old, Emma 7 years old, and James was 6 years old. Each child received one-to-one, home based behavioral intervention programs during the course of the study. All sessions were conducted in the participants' homes.

2.2. Response definitions and measurement

Dependent variables were the percentage of compliance with low-*p* requests, latency to compliance, and task completion time. Percentage of compliance was calculated for every session by dividing the number of compliant responses to low-*p* requests, by the total number of low-*p* requests issued, and multiplying by 100. Low-*p* requests were instructions with which the participant had a history of noncompliance, and high-*p* requests were instructions with which the participant had a history of compliance. Potential high-*p* and low-*p* requests were first identified by the participants' caregivers and subsequently assessed by the first author. During the assessment, the author made eye contact with the participant, issued the request, and recorded whether or not compliance occurred. Five trials of each request were presented, and a percentage of compliance calculated. Percentage scores were used to validate the high-*p* and low-*p* requests categories. High-*p* requests were defined as requests with which compliance had been 80% or greater, and low-*p* requests were defined as requests with which compliance had been 40% or less. High-*p* requests included such instructions as, "give me five", "clap", and "touch tummy".

For Alan, low-*p* requests were "put on your socks" and "put on your shoes". For "put your shoes on", Alan was permitted 60 s following task initiation to put both his shoes on. For "put your socks on", Alan was allowed 60 s following task initiation to put both his socks on. Emma's low-*p* requests were "put your shoes on" and "come here". For "put your shoes on", Emma was permitted 60 s following task initiation to put both her shoes on. For "come here", Emma was allowed 20 s following task initiation to approach the experimenter and compliance was recorded when participant was within 0.5 m of the experimenter. James' low-*p* requests were "put it in the bin" and "sit down". For "put it in the bin", James was permitted 20 s following task initiation to place a tissue into a wastepaper bin. For "sit down", James was allowed a further 10 s to sit on the floor. An incidence of compliance was recorded if participants initiated the requested response within 10 s and completed the low-*p* request within the intervals outlined above. For James, a reduced inter-instruction interval was also used; on these trials, compliance was only recorded if James initiated the requested response within 5 s and completed the request within the specified intervals.

Latency to compliance was defined as the interval between the end of the experimenter's low-*p* request and initiation of the requested task. Latency to and duration of compliance were measured in seconds by the experimenter using a stopwatch. If the participant did not comply with a low-*p* request within 30 s, an incidence of noncompliance was recorded together with a maximum latency of 30 s. Mean compliance latency was calculated for each session by adding the number of seconds from the end of each low-*p* request to the initiation of the requested task, and then dividing by the total number of low-*p* requests issued within the session.

Duration of compliance was defined as the interval between onset of the low-*p* request and completion of the requested task. If the participant did not comply with a request, an incidence of noncompliance was recorded together with a maximum task completion time. Mean duration of compliance was calculated for each session by adding the number of seconds from the initiation of each low-*p* request to the completion of the requested task, and then dividing by the total number of low-*p* requests issued within a session.

2.3. Procedure

2.3.1. Stimulus preference assessment

A multiple presentation preference assessment without replacement (Fisher et al., 1992) was initially used to identify preferred stimuli (tangibles, activities, and edibles). Next, brief multiple presentation preference assessments without replacement were conducted weekly (Carr et al., 2000). Prior to each session, participants chose between the two most highly preferred items (all edibles) identified via that week's preference assessment. Chocolate Buttons® and Rich Tea® biscuits were used with Alan, Smarties® and custard cream biscuits with Emma, and potato crisps and raisins with James.

2.4. Design

A reversal design was used to evaluate the effects of the intervention on compliance and latency to comply with low-*p* requests (ABACABACABAB for Alan for "put your shoes on" and ACABACABAB for "put your socks on", and ABACABACABAB for Emma for "put your shoes on" and ACABACABAB for "come here"). A refers to the baseline of low-*p* requests, B to the high-*p* request sequence with programmed reinforcement, and C to the high-*p* request sequence without programmed reinforcement. A combined alternating treatments with reversal design was used with James (ABACABACABAB for "put it in the bin" and ACABACABAB for "sit down"). During each session, 5 trials with 5 s inter-instruction intervals and 5 trials with 10 s inter-instruction intervals were implemented randomly.

2.4.1. Baseline

During baseline, the experimenter made eye contact with the participant, and issued the low-*p* request. Each low-*p* request was issued five times per session, and compliance was followed by praise and a preferred edible. Incidents of noncompliance were not followed by any programmed consequences.

2.4.2. HPRS with programmed reinforcement (HPRS: SR+)

Here, a series of three randomized high-*p* requests were presented prior to a low-*p* request. High-*p* requests were delivered on a fixed-time (FT) 10-s schedule (an electronic timer prompted the experimenter to issue requests every 10 s). For James, high-*p* requests were delivered on a FT 5 s schedule during those sessions with reduced inter-instruction intervals. Compliance to high-*p* and low-*p* requests was followed with praise and an edible reinforcer. Noncompliance to any of the high-*p* requests lead to the termination of the high-*p* request sequence, and no data were recorded. A new sequence of high-*p* requests was issued until compliance with three consecutive high-*p* requests occurred. A total of five high-*p* request sequences were conducted per session. Each sequence was separated by at least 3 min in order to prevent the occurrence of a high-demand condition due to the repetitive presentation of consecutive requests.

2.4.3. HPRS without programmed reinforcement (HPRS: No SR+)

This condition was identical to the high-*p* request sequence with programmed reinforcement, with the exception that no praise or edibles followed compliance to high-*p* requests. Compliance with low-*p* requests continued to be followed by praise and a preferred edible.

2.4.4. Generalization probes

During the final four intervention sessions, a second (novel) trainer conducted four generalization probes. Conditions were identical to the HPRS: SR+ phase.

2.5. Interobserver agreement

For 48% of Alan's sessions for "put your shoes on", and 52.3% of sessions for "put your socks on", 45% of Emma's sessions for "come here" and 38.7% of sessions for "put your shoes on", and 46.2% of James' sessions for "put it in the bin", and 54.5% of sessions for "sit down" were scored by a second observer in real time who recorded whether the participant complied with the request and the task completion time. Interobserver agreement was calculated by dividing the total number of agreements by the total number of agreements plus disagreements, and multiplying by 100. Interobserver agreement for Alan was 93.6% for "put your socks on" and 95.8% for "put your shoes on", for Emma was 98.9% for "come here" and 95.7% for "put your shoes on", and for James was 96.6% for "sit down" and 94% for "put it in the bin".

2.6. Treatment integrity

Treatment integrity for intervention sessions was calculated by dividing the number of correct steps completed by the experimenter by the total number of steps completed. Treatment integrity was monitored for Alan during 53.5% of sessions for "put your shoes on" and 54% for "put your socks on", for Emma during 50% of sessions for "come here" and 51.8% for "put your shoes on", and for James during 71.43% of sessions for "put it in the bin" and 83.34% for "sit down", respectively. For Alan and James, treatment integrity was 100% across all observed sessions for both low-*p* requests, while for Emma treatment integrity was 98.3% for "come here" and 100% for "put your shoes on".

3. Results

Descriptive statistics (means and standard deviations) of the duration of compliance for low-*p* requests during baseline, HPRS with (HPRS: SR+) and without programmed reinforcement (HPRS: No SR+), with 10 s inter-instruction intervals (10 s), and 5 s inter-instruction intervals (5 s), for each participant, are shown in Table 1.

During baseline, Alan's compliance with "put your socks on" (Fig. 1) was low, the mean latency to compliance was 13.05 s and the mean duration of compliance was 30.08 s. During HPRS without programmed reinforcement, his compliance increased to 52% of trials, mean latency decreased to 9.27 s and mean duration decreased to 23.69 s. Alan's compliance increased to 72% of trials when the HPRS was implemented with programmed reinforcement, the mean latency decreased to 4.075 s and mean duration decreased to 15.89 s. Generalization probes showed that compliance decreased to 55% of trials, mean latency remained low (4.97 s) and mean duration decreased to 13.93 s. Alan's compliance with "put your shoes on" was variable during baseline (33.6% of trials), with a mean latency of 11.22 s, and a mean duration to compliance of 23.92 s. Compliance increased during the HPRS without programmed reinforcement (47.5% of trials), mean latency (7.06 s) and duration decreased (19.33 s). Alan's compliance increased further during the HPRS with programmed reinforcement (90%) and both mean latency (3.39 s) and duration decreased (13.37 s). During generalization probes, compliance remained high (85%) and mean latency (4.45 s) and duration remained low (15.36 s).

During baseline, Emma's compliance with "put your shoes on" (Fig. 2) was low (30%), mean latency was 12.40 s and mean duration of compliance was 19.19 s. In the HPRS without programmed reinforcement, compliance increased (60%) and mean latency (10.13 s) and duration fell (13.69 s). During the HPRS with programmed reinforcement, Emma's compliance increased (80%) and her mean latency (5.32 s) and duration decreased (10.63 s). During generalization, compliance decreased to 75% of trials and mean latency (4.57 s) and duration remained low (10.54 s). Emma's compliance with "come here" was low during baseline (28.5%), her mean latency was 13.22 s and mean duration was 7.78 s. In HPRS without programmed reinforcement, compliance increased (55%) and both mean latency (8.72 s) and duration decreased (6.12 s). In HPRS with programmed reinforcement, compliance increased (95%) and mean latency (2.85 s) and duration further decreased (2.98 s). During generalization, compliance decreased to 75% of trials, mean latency increased (5.09 s) and duration fell (2.77 s) (Fig. 2).

Table 1
Mean (and standard deviation) duration of compliance in seconds for low-*p* requests, during baseline, HPRS with (HPRS: SR+) and without programmed reinforcement (HPRS: No SR+), with 10 s inter-instruction intervals (10 s), and 5 s inter-instruction intervals (5 s), for each participant.

Participant	Low-*p* request	Baseline	HPRS: No SR+	HPRS: SR+	Generalization probes
Alan	"Put your socks on"	30.08 (8.62)	23.69 (6.93)	15.89 (6.47)	13.93 (4.46)
Alan	"Put your shoes on"	23.92 (8.50)	19.33 (6.36)	13.37 (3.91)	15.36 (9.89)
Emma	"Put your shoes on"	19.19 (4.61)	13.69 (3.77)	10.63 (2.48)	10.71 (0.1)
Emma	"Come here"	7.78 (1.42)	6.12 (0.91)	2.98 (1.36)	2.77 (0.32)

Participant	Low-*p* request	Baseline	HPRS: No SR+ 10 s	HPRS: No SR+ 5 s	HPRS: SR+ 10 s	HPRS: SR+ 5 s	Generalization probes: 10 s	Generalization probes: 5 s
James	"Sit down"	6.87 (2.02)	4.63 (0.55)	5.02 (0.36)	3.90 (0.7)	2.92 (0.35)	3.65 (0.32)	3.64 (0.73)
James	"Put it in the bin"	13.21 (1.83)	11.63 (1.11)	10.39 (0.96)	9.42 (0.81)	7.39 (1.86)	7.70 (0.26)	7.14 (0.22)

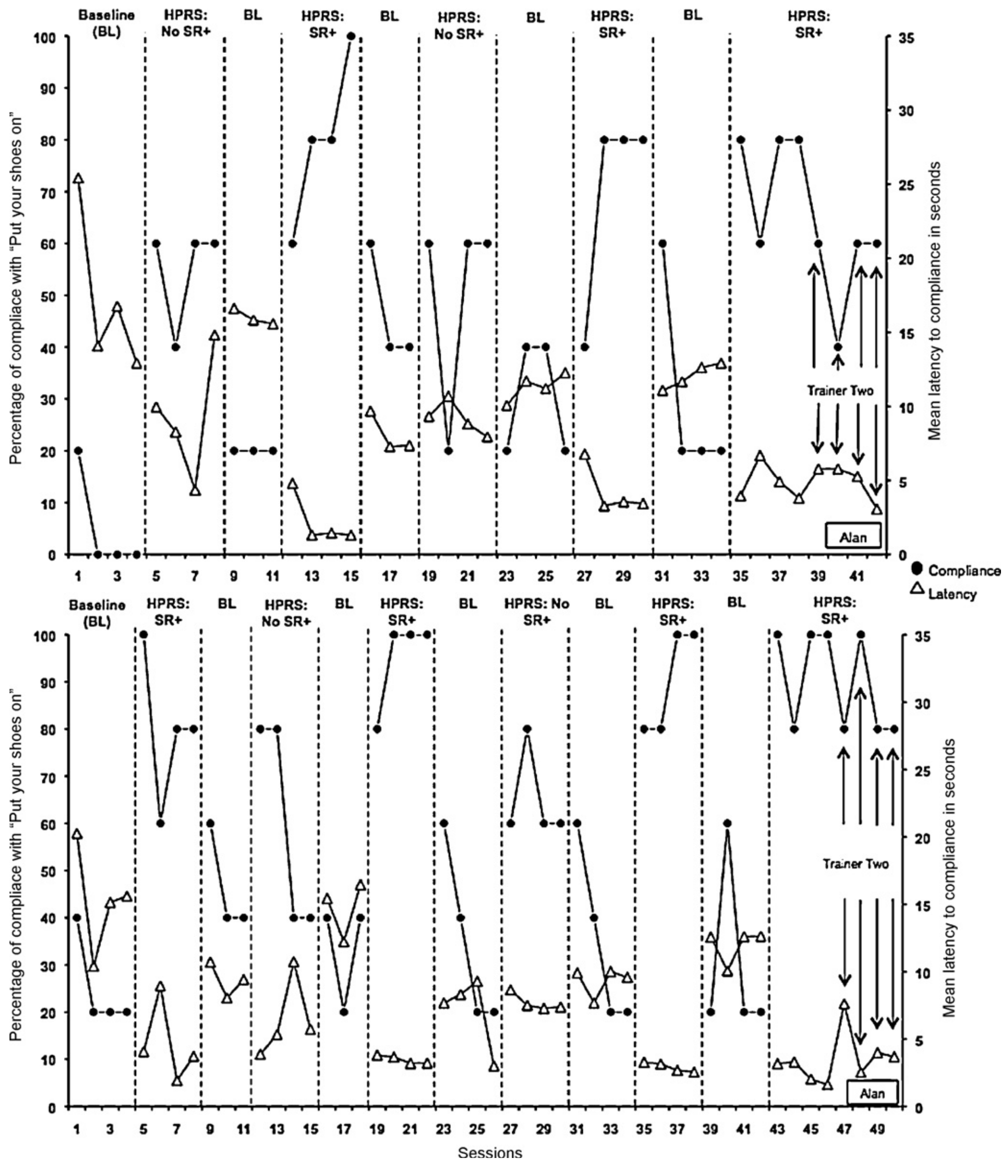

Fig. 1. Alan's percentage of compliance and mean latency to compliance for the low-*p* requests "put your socks on" and "put your shoes on", during baseline, HPRS with programmed reinforcement (HPRS: SR+), and HPRS without programmed reinforcement (HPRS: No SR+). Also shown are generalization probes (Trainer Two) conducted with a second experimenter.

During baseline, James' compliance with "sit down" (Fig. 3, left panel) was low (20%), mean latency was 15.34 s and mean duration was 6.87 s. In HPRS without programmed reinforcement with 10 s inter-instruction intervals, compliance increased (47.5%), mean latency (8.46 s) and duration decreased (4.63 s). In HPRS with programmed reinforcement with 5 s inter-instruction intervals, compliance increased (75%), mean latency (6.46 s) and mean duration decreased (5.02 s). With 10 s inter-instruction intervals, the HPRS with programmed reinforcement increased compliance (91.6%), while both mean latency (4.55 s) and mean duration decreased (3.90 s). When the HPRS with programmed reinforcement was conducted with 5 s inter-instruction intervals, compliance increased (98.3%) and both mean latency (2.78 s) and duration decreased (2.92 s). During generalization probes, compliance was high (80%) when the HPRS with programmed reinforcement was implemented with 10 s inter-instruction intervals, mean latency was 3.98 s and mean duration was 3.65 s. When implemented with 5 s inter-instruction intervals, compliance remained high (95%) and mean latency was 4.05 s and mean duration was 3.64 s.

James compliance with "put it in the bin" (Fig. 3, right panel), was low during baseline (30.8%), mean latency was 13.85 s and mean duration was 13.21 s. During HPRS without programmed reinforcement and with 10 s inter-instruction intervals, compliance increased (57.5%) and mean latency (11.71 s) and duration fell (11.63 s). In HPRS without

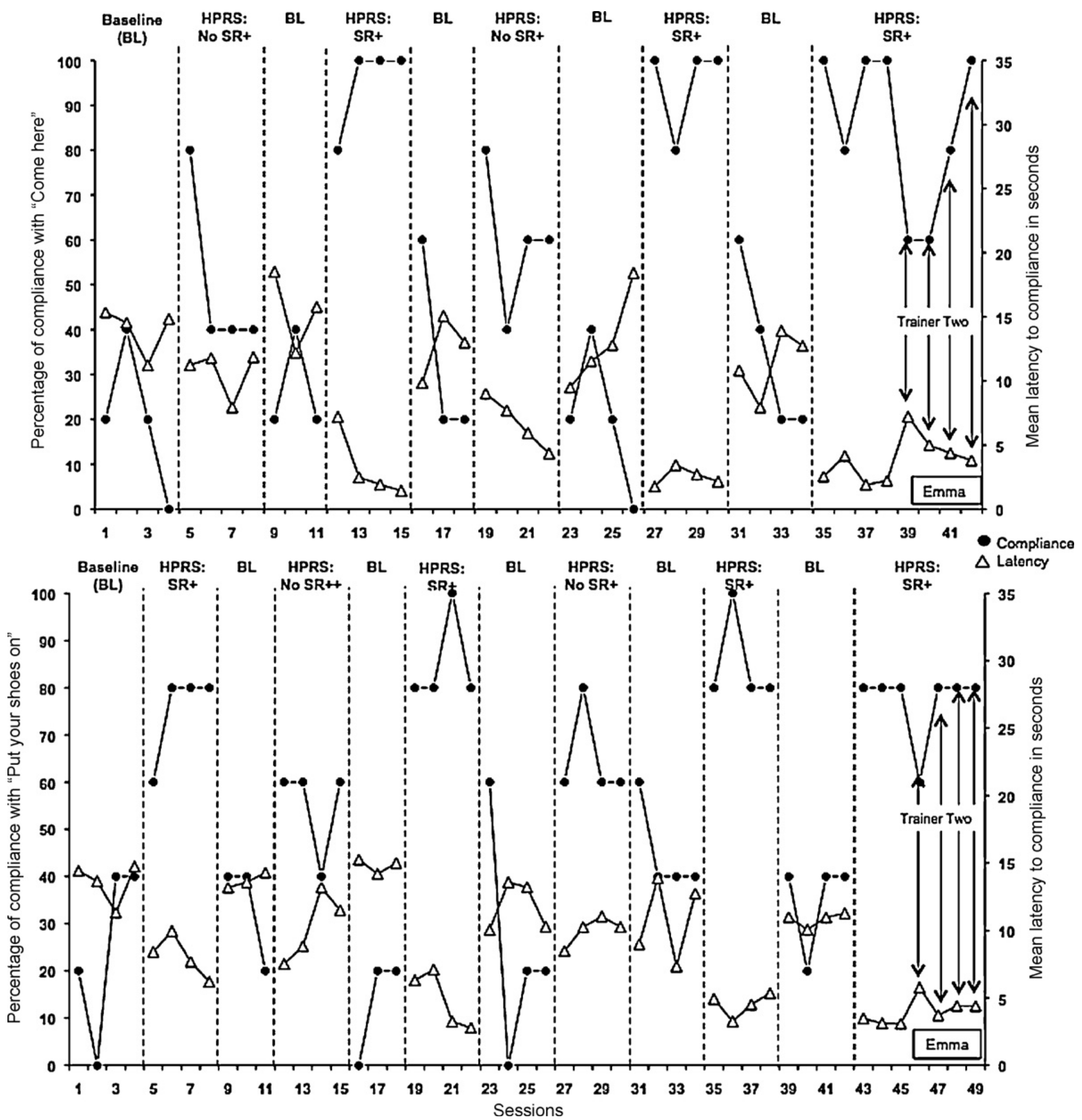

Fig. 2. Emma's percentage of compliance and mean latency to compliance for the low-*p* requests "come here" and "put your shoes on", during baseline, HPRS with programmed reinforcement (HPRS: SR+), and HPRS without programmed reinforcement (HPRS: No SR+). Also shown are generalization probes (Trainer Two) conducted with a second experimenter.

programmed reinforcement, with 5 s inter-instruction intervals, compliance increased (75%), mean latency (6.28 s) and duration (10.39 s) both decreased. During HPRS with programmed reinforcement, with 10 s inter-instruction intervals, compliance was high (81.25%), mean latency (4.37 s) and duration decreased (9.42 s). In HPRS with programmed reinforcement, with 5 s inter-instruction intervals, compliance increased (87.8%), mean latency (3.24 s) and duration decreased (7.39 s). During generalization, when the HPRS with programmed reinforcement was implemented with 10 s inter-instruction intervals, compliance was high (80%), mean latency was 3.90 s and mean duration was 7.70 s. When implemented with 5 s inter-instruction intervals, compliance increased (90%) and both mean latency (2.72 s) and duration decreased (7.14 s).

In summary, compliance to low-*p* requests increased for all three children when completion of preceding high-*p* requests was followed by programmed reinforcement. Latency to compliance decreased during the intervention sessions, particularly during the HPRS with programmed reinforcement. With one participant, brief (5 s) inter-instruction intervals resulted in increased compliance relative to 10 s intervals, and the compliance of all three participants generalized to a second trainer.

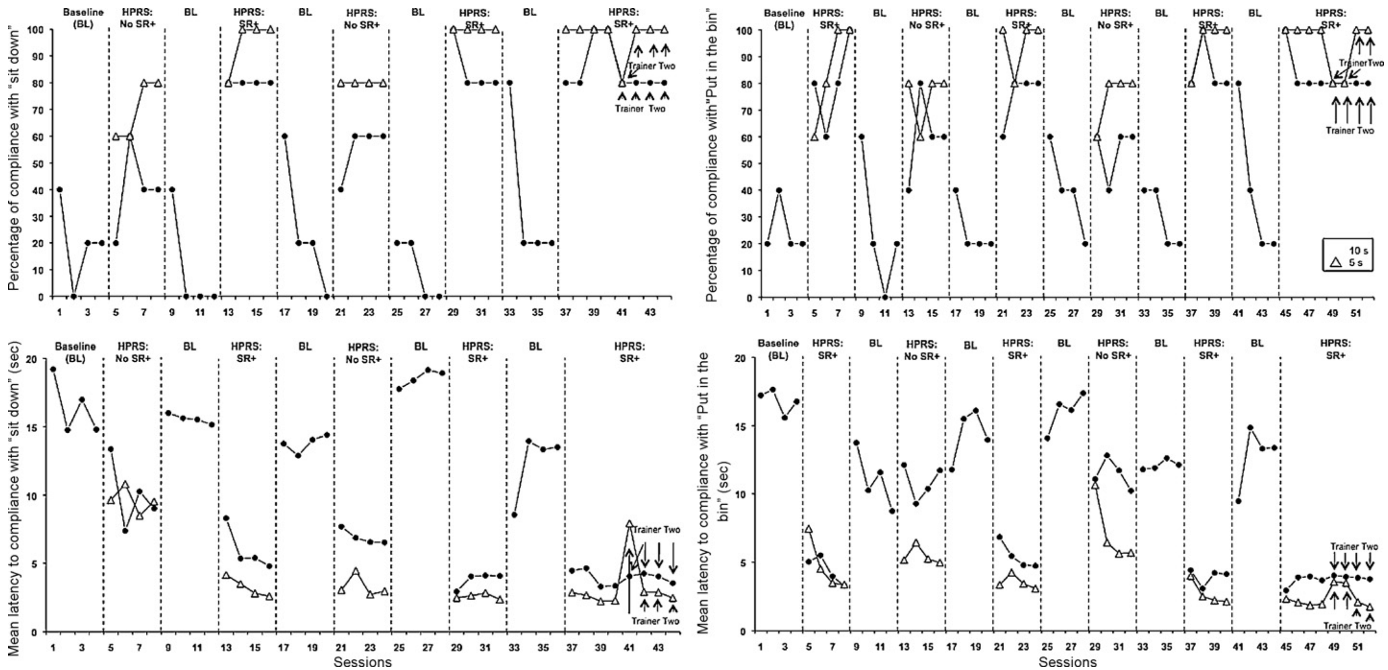

Fig. 3. James' percentage of compliance (upper panels) and mean latency to compliance (lower panels) for the low-*p* requests "sit down" and "put it in the bin", during baseline, HPRS with (HPRS: SR+) and without programmed reinforcement (HPRS: No SR+) with 5 s (open triangles) and 10 s (closed circles) inter-instruction intervals. Also shown are generalization probes (Trainer Two) conducted with a second experimenter.

4. Discussion

The present findings demonstrate that the HPRS was most effective in increasing compliance to low-*p* requests when implemented with programmed reinforcement. These results are consistent with previous research, indicating that reinforcement is an important component within the HPRS (Mace et al., 1997; Zuluaga & Normand, 2008). The present study also found the HPRS to be most effective in reducing compliance latency and task completion time when implemented with programmed reinforcement. Implementing the HPRS with programmed reinforcement could have a significant impact on an individual's learning, as reducing compliancy latency and task completion times means learning time can be utilized more effectively, potentially leading to increases in fluency and higher rates of skill acquisition (Belfiore, Lee, Scheeler, & Klein, 2002; Mace et al., 1988).

Our findings suggest that inter-instruction interval is an important component within the HPRS. Results indicated that a shorter inter-instruction interval of 5 s to that employed previously was most effective in increasing compliance to low-*p* requests and in decreasing compliance latency and total task completion time. We also showed that when another trainer was introduced to implement the HPRS, generalized responding occurred for all but one of the participant's low-*p* requests. Typically, compliance with low-*p* requests decreased on the first session with the second trainer, but quickly increased during subsequent sessions to levels comparable to or in some instances higher than levels achieved by the primary trainer (the first author). The compliance latency and task completion measures were also similar to, or in some instances, lower than those recorded by the primary trainer. Taken together, our findings add to those of Davis, Brady, Williams, and Hamilton (1992) who showed that increases in compliance with low-*p* requests generalized to another trainer who had not previously used the HPRS with the participant. The findings from the generalization probes warrant further extension by, for instance, assessing generalization of across behaviors, settings, and trainers including parents, caregivers, and teachers (Stokes & Baer, 1977).

In the present study, escape-related behavior reduced during sessions where the HPRS was implemented, according to anecdotal observations. This may be partly explained by the fact that some of the behaviors involved in complying with the issued requests were topographically incompatible with escape-maintained behavior and, thus, increases in compliance would naturally have led to reductions in escape-related behavior (Mace & Belfiore, 1990). In addition, reported reductions in escape-related behavior may be attributed to the increased density or availability of reinforcement for compliance during the HPRS. This is consistent with previous research suggesting that the increased availability of reinforcement, such as a preferred edible, may act as an abolishing operation for escape and, hence, lead to escape being less reinforcing and unlikely to occur (Bullock & Normand, 2006; Lalli et al., 1999). Future studies would be well advised to formally investigate the effects of the HPRS on escape-related behavior by, for instance, conducting a prior functional analysis, and in instances where a participants' motivation for escape is particularly high, investigating the effects of the HPRS with and without programmed reinforcement and of an extinction component.

A potential limitation of the current study concerns the measure of task completion time, which may have been susceptible to practice effects. It is possible repeated completion of a particular task could lead to reductions in completion times, regardless of the intervention. Another related potential limitation concerned the upper threshold limits placed on the measures of compliance latency and task completion. It remains unclear whether or not the maximum compliance latency and task completion time limits may have made incidences of compliance and noncompliance indistinguishable and potentially ameliorate the effect of the intervention. Future research on this issue is warranted.

4.1. Conclusions

Overall, the present findings demonstrate that programmed reinforcement is a critical component in increasing compliance with low-*p* requests and in reducing compliance latency and task completion time. Our findings show that brief, 5 s inter-instruction intervals produce greater increases in compliance to low-*p* requests (although this effect was observed with only one participant) and indicate that implementing the HPRS with programmed reinforcement and short inter-instruction intervals may be the most effective way of increasing compliance. Finally, the present study highlights the importance of using high quality preferred reinforcement formally identified via stimulus preference assessments. Future studies are advised to consider adopting these procedures as part of interventions to increase child compliance.

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