

Increasing Behavioral Variability and Social Skill Accuracy in Children with Autism Spectrum Disorder

Keith C. Radley¹ · Allison A. Battaglia¹ · Komila Dadakhodjaeva¹ · W. Blake Ford¹ · Kristi Robbins¹

Published online: 27 February 2018
© Springer Science+Business Media, LLC, part of Springer Nature 2018

Abstract Although social skills training for children with autism spectrum disorder (ASD) often addresses deficits in social communication, restricted and repetitive social behaviors are less frequently targeted in the literature. The present study evaluated a manualized social skills training program, modified to incorporate lag schedules of reinforcement, to promote appropriate and variable responding in three children in a school setting. Participants attended social skills once weekly, with probes of social skills taking place daily. A multiple baseline design across target skills was used to determine intervention efficacy. Results of the study indicated that the social skills curriculum incorporating lag schedules of reinforcement resulted in substantial increases in the number of appropriate and variable responses demonstrated by participants during each probe session, as well as the number of appropriate and variable responses demonstrated overall.

Keith C. Radley is a co-author of the Superheroes Social Skills program. The Superheroes Social Skills program was developed for the Utah State Office of Education as part of his doctoral training. Keith C. Radley does not benefit, financially or otherwise, from the commercial sale of the program, nor was the data included in the article part of research funded by the commercial publisher.

✉ Keith C. Radley
keith.radley@usm.edu

Allison A. Battaglia
Allison.battaglia@usm.edu

Komila Dadakhodjaeva
komila.dadakhodjaeva@usm.edu

W. Blake Ford
William.b.ford@usm.edu

Kristi Robbins
Kristi.robbs@usm.edu

¹ Department of Psychology, University of Southern Mississippi, 118 College Drive # 5025, Hattiesburg, MS 39406-001, USA

Keywords Autism spectrum disorder · Social skills · Lag schedule

Introduction

Restricted and repetitive behavior and impairments in social communication are diagnostic of autism spectrum disorder (ASD, American Psychiatric Association, 2013). These characteristics can co-manifest across domains, presenting problems across numerous settings and situations. For example, limitations in social contexts can go beyond difficulties in appropriately joining in conversations, as individuals with ASD often demonstrate restrictive communicative behavior that may result in reduced access to reinforcement (e.g., Creak 1972; Mercier et al. 2000; Wolfe et al. 2014). As such, individuals with ASD often require social supports beyond simple training in accurate demonstration of target social skills, but also may benefit from training that targets increasing the number of appropriate exemplars of a discrete behavior that an individual may demonstrate. Given that restricted and repetitive behaviors may result in negative outcomes (e.g., repetitive use of failed problem solving strategies, failure to modify behaviors in accordance with changes in the environment, aversiveness to peers; Mercier et al. 2000; Parsonson and Baer 1978; Wolfe et al. 2014), improving appropriate variability of discrete social skills may result in clinically meaningful outcomes for individuals with ASD.

Social skills training is frequently utilized to address symptoms of ASD (e.g., Hess et al. 2008). Substantial research has targeted improving the accuracy with which discrete social skills are demonstrated, with procedures such as video modeling, behavioral skills training, and self-monitoring being found to meet criteria for evidence-based practice (e.g., Rao et al. 2008; Reichow and Volkmar 2010; Wang and Spillane 2009). Although few studies have included variable responding as an outcome of social skills training, those studies have found response variability in individuals with ASD to be restricted and repetitive unless specific intervention strategies are implemented to increase response variability (e.g., Betz et al. 2011; Sellers 2011; Radley et al. 2017). Whereas research addressing invariant social behaviors in individuals with ASD is less common than interventions addressing skill accuracy (e.g., Wolfe et al. 2014), one of the most frequently evaluated strategies for addressing invariant social behavior in individuals with ASD is the use of lag schedules of reinforcement (e.g., Lee et al. 2002; Lee and Sturmey 2006; Susa and Schlinger 2012).

Lag schedules of reinforcement describe a contingency in which reinforcement is delivered following a response that differs from N number of immediately preceding responses (Lag N). For example, a fixed-ratio 2 (FR 2) schedule of reinforcement, in which reinforcement is delivered following two correct responses, may be utilized to promote accurate responding of children with ASD (e.g., Lane et al. 2015). Utilizing a Lag 2 schedule, reinforcement would only be provided following the demonstration of a response that was accurate and that differed from both of the previous responses. In a recent example, Lepper et al. (2016) utilized lag schedules of reinforcement to address restricted conversational interests

of two children with ASD. In both participants, introduction of lag schedules of reinforcement was associated with increases in conversation regarding topics unrelated to circumscribed interests.

Despite burgeoning empirical support for the use of lag schedules to address invariant behavior in individuals with ASD, these practices may go unutilized in applied settings unless incorporated into intervention curricula (Dingfelder and Mandell 2011; Kasari and Smith 2013). To our knowledge, no social skills training curricula currently incorporates lag schedules to address restricted and repetitive behaviors. However, extant social skills curricula may be modified by researchers and practitioners to include lag schedules. In a clinic-based social skills group, Radley and colleagues (2017) utilized a modified version of the Superheroes Social Skills program (Jenson et al. 2011) incorporating lag schedules to increase novel responding for four target social skills. Similar to prior evaluations of the program (e.g., O’Handley et al. 2016; Radley et al. 2015), Radley and colleagues found that implementation of the curriculum without lag schedules resulted in increased skill accuracy. However, little improvement in the number of appropriate exemplars demonstrated by participants was observed, despite the fact that multiple exemplars of each target skill were modeled as part of the curriculum. Next, the researchers continued training with multiple exemplars but also implemented a lag schedule. The researchers first introduced the lag schedule by telling participants that a certain number of variable responses, corresponding with the lag schedule, was necessary to access reinforcement. Upon implementation of the lag schedule, substantial improvements in the level of appropriate variability were noted. The researchers also found that increasing lag schedule requirements resulted in further increases in the level of appropriate variability demonstrated by participants. Despite increases in variable responding during implementation of lag schedules, appropriate variability was generally not maintained following removal of contingencies. Despite promising findings, the provision of a rule by the researchers regarding access to reinforcement limits conclusions that may be drawn regarding the effect of the lag schedule itself.

Radley and colleagues (2017) provided a model for modification of extant social skills curricula to incorporate lag schedules. Although the study provides an important model, the training setting (i.e., university-based clinic) and intensity of procedures (i.e., 2 h twice per week) limit generalization of findings regarding efficacy and feasibility to more authentic settings where such high levels of intervention intensity may not be feasible (e.g., Whalon et al. 2015). Given the limitations of Radley and colleagues (2017), the purpose of the present study was to determine whether implementation of the Superheroes Social Skills curriculum modified to include lag schedules and to be delivered in brief, once-weekly training over approximately 8 weeks within a school setting would result in similar levels of improvement in appropriate and variable responding. Further, the current study sought to determine whether increased variability would be observed when utilizing the Superheroes Social Skills curriculum modified to incorporate lag schedules of reinforcement without the provision of a rule regarding access to reinforcement under the lag schedule.

Methods

Prior to the recruitment of participants, approval for the study was obtained from the affiliate university's Institutional Review Board. Three participants were referred to a district-based behavioral consultant by school administrators for social skills training. All three participants had a special education classification of Autism at the time of referral for social skills training. Ned was a 11-year-old African-American male in the sixth grade. Suzy was a 12-year-old African-American female in the sixth grade. Ward was a 12-year-old African-American male in the sixth grade. All students were primarily educated in regular education classrooms, but received supplemental speech, language, and counseling services at school.

All study procedures took place in a middle school in the southeastern USA. A total of 302 students were enrolled in the school at the time of the study. Of the students, 54% were female and 46% were male, with 91% of students identifying as African-American, 4% as Caucasian, 4% as Hispanic, and 1% as Asian or Pacific Islander. All of the student body was eligible for free or reduced lunch. The middle school offered intensive science, technology, engineering, art, and math programs. Social skills training took place in a small classroom measuring approximately 10 m by 10 m. The room contained a round table and chairs in the center of the room. Additionally, a 13-inch laptop computer was present in the training setting. The room also contained a dry erase board, which was not used during the study. Probes took place in a different classroom from the one used for social skills training and in the hallway outside the participants' classrooms. All probes, regardless of condition, were conducted in the same setting during each probe session.

Materials

Materials utilized in the current study were limited to those included in the Superheroes Social Skills program. These materials included instructional videos presented via DVD and reinforcer tokens. Small tangible reinforcers (e.g., pencils, small toys, stickers) were provided to students for meeting lag schedule requirements. Reinforcers utilized in the current study were identical to reinforcers utilized by participants' teachers within the classroom.

Dependent Measures

Appropriate and Variable Responses per Session

The primary dependent variable measured was the number participant responses that met criteria for being both appropriate and variable. Responses were determined to be appropriate if they allowed the individual entry into or continued reciprocal engagement, contact with the consequence of the social behavior, and caused no disruption to the activity. For example, the response of "Angry, because someone stole

my pencil” would be considered contextually appropriate for the question “How are you feeling today,” whereas “I need a pencil” would not be considered appropriate. A response was considered variable if it was topographically different than other responses demonstrated during the same probe session. Responses that shared words with another response were considered to vary if omission of the shared words resulted in a different response. For example, if a probe consisted of the statement “I got an F on my test,” the responses “Can I help you study for the next test?” and “Can I help you do better?” would both be considered appropriate and variable as the omission of the words “Can I help you?” results in two distinct offers for assistance (i.e., “study for the next test” and “do better”). Responses which only varied by omission of some words from a previous response (e.g., “Can I help you study?” and “Can I help?”) would not be considered topographically different. However, addition of words to a previous response (e.g., “Great” and “Great, because it is recess time”) would be considered topographically different.

The three target skills included in the present study, selected due to teacher-report of social skill deficits common to all three participants, were Expressing Wants and Needs, Perspective Taking, and Recognizing and Expressing Emotions. Each skill trained in the study was composed of multiple discrete steps. Appropriate and variable responding was only assessed as part of one or two steps for each of the skills (see Table 2). For Expressing Wants and Needs, appropriate and variable responding was assessed during the final step (i.e., say what is wanted or needed). Variations in request frame were considered to be appropriate and variable. For example, “Mr. Fox, can I draw” and “Excuse me, can I draw” were considered appropriate and variable. For Perspective Taking, appropriate and variable responding was assessed during the fifth step (i.e., offer assistance). For Recognizing and Expressing Emotions, appropriate and variable responding was assessed during the third and fourth steps (i.e., state emotion, provide description for feeling). During each probe session, a total of 10 probes were administered for each skill trained (i.e., 30 probes across the three target skills). As such, a score of 10 would signify that all participant responses for one skill were both appropriate and varied from all other responses provided during that same probe session for the same skill. Using actual participant responses for Recognizing and Expressing Emotions, examples of participant responses resulting in different numbers of appropriate and variable responses are presented in Table 1.

All probes were conducted by a school psychology doctoral student. To probe skills, researchers provided a scenario in which the participant was able to demonstrate the target skill. For Expressing Wants and Needs, a researcher provided the direction “Go ask (name of other researcher) for something.” The probe for Perspective Taking consisted of a researcher making a disappointed face and stating “I got an F on my test” while in the proximity of the participant. Similarly, the probe for Recognizing and Expressing Emotions consisted of a researcher asking a participant “How are you feeling today?” Following each probe, researchers recorded the participants verbal and nonverbal response verbatim. At the end of each probe session, each response for a particular skill was compared to all other responses for that same skill and the number of appropriate and variable responses was determined. Data were then graphed as the number of probes in which appropriate and variable responding was observed.

Table 1 Examples of differing numbers of appropriate and variable responses for Recognizing and Expressing Emotions

Four appropriate and variable responses	Seven appropriate and variable responses	Ten appropriate and variable responses
“Great”	“Good”	“Great”
“Good”	“Great, because today is Monday”	“Great, because we get to go outside today”
“Awesome”	“Great, because it’s almost Christmas”	“Terrific, because it’s almost Friday”
“Good”	“Super”	“Good, because I just got an A+”
“Outstanding”	“Happy, because I’m going to a birthday party today”	“Happy, because I get to go play at recess”
“Awesome”	“Happy”	“Happy, because I might get another dog”
“Good”	“Fine”	“Great, because I got a new pencil”
“Great”	“Good”	“Hungry, because I didn’t get breakfast”
No response	“Great, because it’s nice weather today”	“Super, because I get to go outside”
No response	“Super”	“Tired, because I didn’t get enough sleep”

Responses in bold recorded as appropriate and variable

Cumulative Number of Appropriate and Variable Responses

In addition to assessing the number of appropriate and variable responses demonstrated per probe session, a cumulative tally of appropriate and variable responses was calculated for each skill across all sessions. In order to calculate the cumulative number of appropriate and variable responses, each response was compared to all previous responses across the entire treatment evaluation for the same skill. If a response was both appropriate and variable in comparison with all previous responses (i.e., participant had never before provided that particular response), the cumulative count increased by one. Responses that were either inappropriate or repeated resulted in no change to the cumulative count.

From the cumulative number of appropriate and variable responses, the number of appropriate and variable responses per probe within each phase was calculated for each skill by participant. This was determined by determining the number of appropriate and variable responses within a phase and dividing that number by the total number of probes within that same phase. For example, if 16 appropriate and novel responses were provided during a phase in which 180 total probes were delivered, the appropriate and variable responses per probe would be 0.09.

Skill Accuracy

Accuracy of discrete skill steps was assessed during each probe as a tertiary dependent variable. Each skill included as part of the study consisted of multiple steps.

Table 2 Task analyses of target skills

Expressing wants and needs	Perspective taking	Recognizing and expressing emotions
<ol style="list-style-type: none"> 1. Face the person with head and shoulders oriented toward partner 2. Make and sustain eye contact for a minimum of 3-s 3. Wait for a pause in the conversation without interrupting 4. Give a signal that you want to talk (e.g., raise hand, tap shoulder twice, say person’s name) 5. Wait for the person to respond to the signal 	<ol style="list-style-type: none"> 1. Face the person with head and shoulders oriented toward partner 2. Make and sustain eye contact for a minimum of 3-s 3. Ask how the conversation partner feels 4. Wait for the conversation partner to respond without interrupting 5. Offer assistance (e.g., ask how you can help, propose a solution) 	<ol style="list-style-type: none"> 1. Face the person with head and shoulders oriented toward partner 2. Make and sustain eye contact for a minimum of 3-s 3. State the emotion, beginning with “I feel...” 4. Provide description for the feeling, continuing with “because...”
<p>6. Say what is wanted/needed</p>		

Steps during which appropriate and variable respond were assessed in bold

Following the delivery of a prompt to demonstrate the target skill, the accurate demonstration of each skill was assessed using a Superheroes Social Skills manual-derived task analysis (Table 2). The percentage of skill steps accuracy demonstrated was calculated by dividing the number of skill steps completed by the number of steps identified in the task analysis for a skill and multiplying by 100. Skill accuracy was assessed simultaneously with appropriate and variable responding during each probe.

Interobserver Agreement

A second group facilitator independently recorded appropriate and variable responding and skill accuracy to allow for determination of interobserver agreement (IOA) during a minimum of 20% of probes per phase. For appropriate and variable responding, IOA was calculated by dividing the raters' agreements regarding appropriate and variable responding (i.e., yes, the response was appropriate and variable; no, the response was not appropriate or variable) by the number of agreements and disagreements and multiplying by 100. IOA for skill accuracy was calculated by dividing the number of agreements regarding skill steps completed by the number of agreements plus disagreements and multiplying by 100.

For Ned, IOA was collected during 28% of probes. A mean IOA of 100% for appropriate and variable responding and 87% (range 80–100%) for skill accuracy was documented. For Suzy, IOA was collected during 32% of probes with a mean of 100% for appropriate and variable responding and 91% (range 80–100%) for skill accuracy. For Ward, IOA was collected during 31% of probes with a mean of 100% for appropriate and variable responding and 97% (range 90–100%) for skill accuracy.

Design

A multiple baseline design across skills design was utilized to assess the effects of social skills training with an embedded lag schedule on the number of appropriate and variable responses per session, cumulative number of appropriate and variable responses, and skill accuracy. The design consisted of three phases: baseline, intervention, and maintenance. Due to scheduling associated with the end of the semester, no maintenance data were collected for Suzy for Recognizing and Expressing Emotions, and only one maintenance data point was collected for Ward for the same skill. Phase changes were made based on visual analysis of data regarding the number of appropriate and variable responses per session.

Procedures

Baseline

Prior to collection of baseline data, teachers of participants were asked to complete the Autism Social Skills Profile (ASSP; Bellini and Hopf 2007). Items on the ASSP that were scored the lowest, indicating social skill deficits, were utilized to identify

corresponding target skills from the Superheroes Social Skills curriculum. Due to common deficits reported across all participants, Expressing Wants and Needs, Perspective Taking, and Recognizing and Expressing Emotions skills from Superheroes Social Skills were selected as target skills. Following the identification of target skills, baseline probes were conducted to assess appropriate and variable responding and skill accuracy. During baseline probes, praise was provided to participants for compliance. No performance feedback was provided, however, regarding accurate or inaccurate demonstration of the skill or restricted responding. A minimum of a 15-s intertrial interval was provided between probes. As previously described, 10 probes were conducted for each skill during each baseline session, with probes alternating between target skills.

Intervention

During the intervention phase, participants attended a once-weekly social skills training group. Sessions were 30-min in duration and facilitated by a school psychology doctoral student who served as a behavioral consultant to the school district. Except for modifications made to include the lag schedule, the Superheroes Social Skills program was implemented as described in the implementation manual (Jenson et al. 2011).

Social skills training groups were held on the same day each week during the intervention phase. Immediately prior to each intervention session, baseline and maintenance probes were conducted for skills in those conditions, with probes alternating between skills. Once baseline and maintenance probes were completed, participants were welcomed to the training group and shown the group rules and schedule for the day. Next, participants viewed an animated video via the laptop computer in which cartoon superheroes described the rationale and steps to use the target skill. Participants then viewed video models of unknown children and adolescents demonstrating the target skills. Following viewing the videos, the group facilitator modeled three variations of the target skill (Table 3). Each of the modeled responses consisted of two parts, with variations being modeled for each part of the response.

Table 3 Two-part responses modeled by facilitator

Response part	Expressing wants and needs	Perspective taking	Recognizing and expressing emotions
Part A	1. Tap on shoulder	1. “Are you (emotion)?”	1. “Happy”
	2. Say name	2. “How are you feeling?”	2. “I feel sad”
	3. “Excuse me”	3. “What’s wrong?”	3. “I am angry”
Part B	1. “Can I...”	1. “Can I help you study?”	1. “Because I got an A on my test”
	2. “May I...”	2. “Is there anything I can do?”	2. “Because I lost my dog”
	3. “Is it okay if...”	3. “How can I help?”	3. “Because someone stole my pencil”

Participants then engaged in three to five role plays of the target skill with the facilitator and other participants. During role play, participants were provided with praise for accurate skill demonstration. If participants failed to provide a response that was appropriate and variable in comparison with the previous response, participants were given the prompt “You said that before, try a different response next time.” Next, participants viewed an animated comic book video in which one of the superhero characters modeled use of the target skill and reemphasized the rationale for skill use.

Before returning to their classroom, probes were conducted with each participant individually for the skill in training. During the first probe, participants earned a “power charge” token if they provided an appropriate response. Delivery of a token was not contingent upon variable responding, as no previous responses had been emitted during that session to which the response could be compared (Wolfe et al. 2014). During the remainder of the probes during that same session, participants earned a token following each response that met Lag 1 requirements (i.e., response varies from the immediately preceding response). Following responses that did not meet the Lag 1 requirement, participants were provided with feedback, “You said that before, try a different response next time,” and no token was provided. A minimum of a 15-s intertrial interval was provided between probes. At the conclusion of 10 probes, participants that had accumulated a minimum of 5 tokens were eligible to select a reinforcer.

Probes were also collected on days when social skills instruction was not provided. As during probes that followed social skills instruction, probes were conducted individually and in the same setting. The first day following training, a Lag 1 schedule was repeated. If participants met lag schedule requirements during at least 80% of probes during this day, the lag schedule requirements were increased to Lag 2 for the probe session. All participants immediately met this requirement across all skills. During the following probe session in which Lag 2 was in place, tokens were provided based only on appropriate responding during the first response (i.e., identical to Lag 1). During the second probe, tokens were provided following responses that were appropriate and variable from the response during the first probe. During the third and all subsequent probes, tokens were provided following responses that met Lag 2 requirements. If participants met Lag 2 requirements during at least 80% of probes during this day, the lag schedule requirements were increased to Lag 3 during the next probe session. All participants immediately met this requirement across skills. During the following probe session, Lag 3 requirements were in place. All participants met the lag schedule requirements during at least 80% of probes across skills when the requirements were increased to Lag 3. During the next probe session, the schedule requirement was increased to Lag 4. Once the lag schedule requirement had been increased to Lag 4, that schedule requirement remained in place for the duration of the study. In other words, participants were exposed to Lag 1 during the first and second intervention phase probe session, Lag 2 during the intervention phase probe session, Lag 3 during the fourth intervention phase probe session, and Lag 4 for the remaining intervention phase probe sessions. Regardless of the lag schedule in place, participants who accumulated a minimum of five tokens were eligible to select a reinforcer. If participants accumulated less than five tokens,

they would not have been eligible to select a reinforcer. However, this did not occur at any point during the study.

Maintenance

Maintenance phase data were collected once direct instruction in a particular target skill was discontinued. A minimum of a 15-s intertrial interval was provided between probes. As with baseline probes, no performance feedback (e.g., praise or error correction) or tokens for meeting lag schedule requirements were provided to participants.

Treatment Integrity

Treatment integrity was assessed through facilitator completion of an integrity checklist (Appendix A) during each training and probe session. Integrity was calculated by dividing the number of steps completed by the total number of possible steps and multiplying by 100. Mean integrity was 100% across experimental phases. In addition, IOA for treatment integrity was calculated by having a second group facilitator complete a treatment integrity checklist during each training session and during at least 20% of probe sessions per phase. IOA was calculated by dividing the number of agreements of steps completed by the number of agreements and disagreements multiplied by 100. IOA for treatment integrity was 100%.

Results

Appropriate and Variable Responses per Session

The primary dependent variable was the number of appropriate and variable responses per session. Figure 1 presents the results for the number of appropriate and variable responses per session for Ned. During the baseline phase, Ned exhibited low, stable levels of appropriate and variable responses for Expressing Wants and Needs ($M = 0.16$; range 0–1) and Perspective Taking ($M = 0.0$). However, he demonstrated moderate to high levels of appropriate and variable responses with high variability for Recognizing and Expressing Emotions ($M = 6.8$; range 4–9). Following implementation of intervention, immediate and large increase in level of appropriate and variable responses were observed for Expressing Wants and Needs ($M = 9.6$; range 8–10) and Perspective Taking ($M = 9.3$; range 8–10). An immediate and moderate increase in appropriate and variable responses for Recognizing and Expressing Emotions was observed ($M = 9.5$; range 8–10). During the maintenance phase Ned exhibited slightly decreased levels of appropriate and variable responses with greater variability compared to the intervention phase for Expressing Wants and Needs ($M = 9$; range 7–10). For Perspective Taking ($M = 7.5$; range 5–10) and Recognizing and Expressing Emotions ($M = 8.7$; range 8–9), he demonstrated

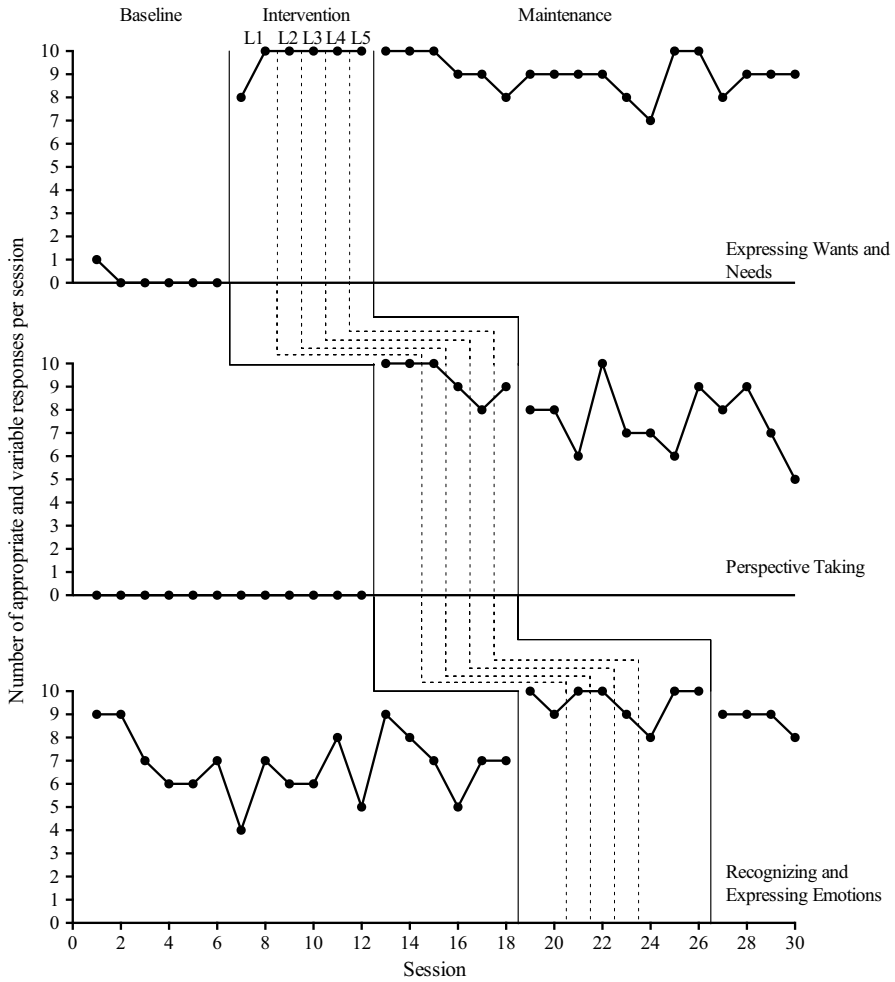


Fig. 1 Number of appropriate and variable responses per session, Ned

slight decreases in level of appropriate and variable responses with slight decreasing trends.

The results for Suzy’s number of appropriate and variable responses per session are presented in Fig. 2. Suzy demonstrated low levels of appropriate and variable responses for Expressing Wants and Needs ($M = 2.2$; range 0–3) during baseline. Additionally, she provided low to moderate levels of appropriate and variable responses per session with high variability across sessions for Perspective Taking ($M = 3.17$; range 0–7) and moderate levels of appropriate and variable responses per session for Recognizing and Expressing Emotions ($M = 4.8$; range 3–7). An immediate increase in number of appropriate and variable responses was observed for all skills following the implementation of social skills training and the lag schedule.

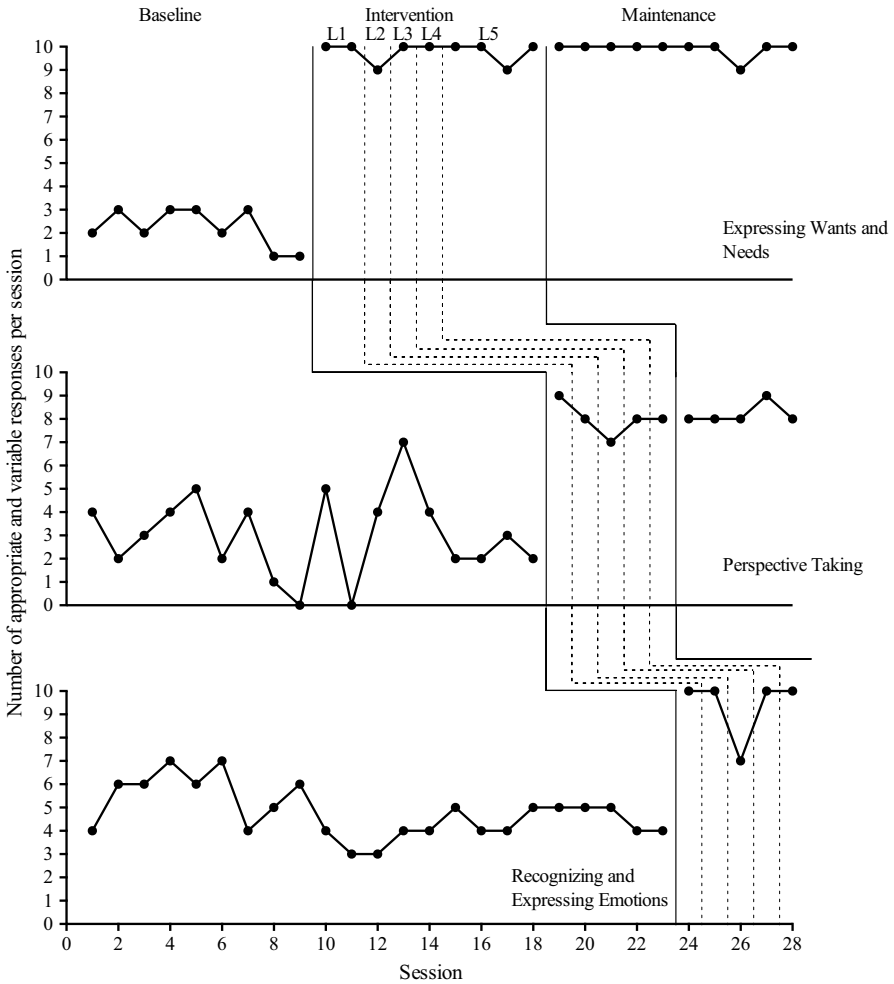


Fig. 2 Number of appropriate and variable responses per session, Suzy

Furthermore, elevated levels of appropriate and variable responding maintained with no change in trend or variability for Expressing Wants and Needs ($M = 9.7$; range 9–10), Perspective Taking ($M = 8.0$; range 7–9), and Recognizing and Expressing Emotions ($M = 9.4$; range 7–10). Finally, the results were maintained at similar levels and stability during the maintenance phase for Expressing Wants and Needs ($M = 9.9$; range 9–10) and Perspective Taking ($M = 8.2$; range 8–9). There were no maintenance data for Recognizing and Expressing Emotions.

The number of appropriate and variable responses per session for the three target skills for Ward is displayed in Fig. 3. During baseline, Ward demonstrated low levels of appropriate and variable responses for Expressing Wants and Needs by providing only one appropriate and variable response during all except the first

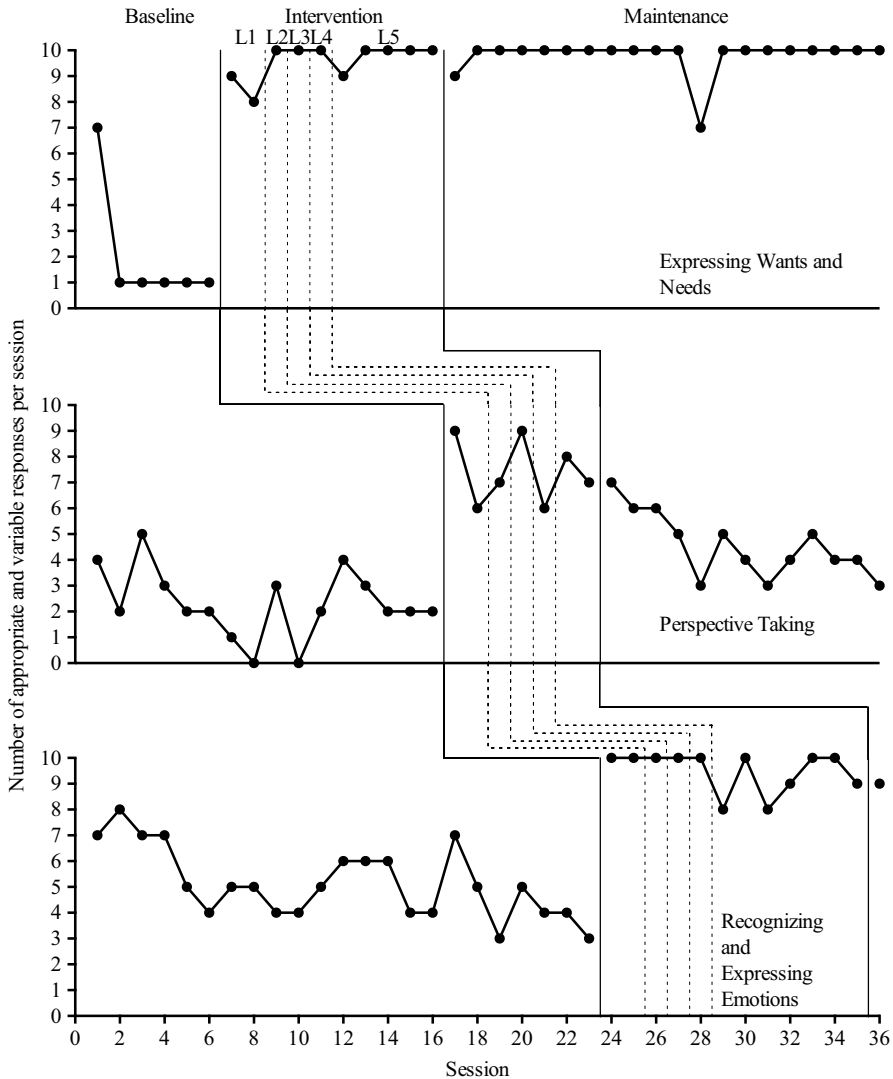


Fig. 3 Number of appropriate and variable responses per session, Ward

session (7 appropriate and variable responses). For Perspective Taking, Ward displayed low to moderate levels of appropriate and variable responses per session and moderate variability ($M = 2.3$; range 0–5). Finally, the number of appropriate and variable responses for Recognizing and Expressing Emotions was moderate to high with a decreasing trend ($M = 5.18$; range 3–8). Following introduction of the social skills training with a lag schedule of reinforcement, Ward demonstrated immediate increases in level of appropriate and variable responses across all target skills. The number of appropriate and variable responses per session ranged from 8 to 10 for

Expressing Wants and Needs ($M = 9.6$) and Recognizing and Expressing Emotions ($M = 9.5$), and from 6 to 9 appropriate and variable responses per session for the Perspective Taking skill ($M = 7.4$). During the maintenance phase, Ward maintained high levels of appropriate and variable responses for Expressing Wants and Needs ($M = 9.8$; range 7–10). He provided nine appropriate and variable responses for the one maintenance session for Recognizing and Expressing Emotions skill. However, Ward demonstrated a decreased level and a decreasing trend for appropriate and variable responses during the maintenance phase for Perspective Taking ($M = 4.5$; range 3–7).

Cumulative Number of Appropriate and Variable Responses

The cumulative number of appropriate and variable responses for Ned is presented in Fig. 4. For Expressing Wants and Needs and Perspective Taking, he demonstrated one (0.01 per baseline phase probe) and zero appropriate and variable response during the baseline phase, respectively. During baseline, Ned demonstrated 16 cumulative appropriate and variable responses for Recognizing and Expressing Emotions (0.09 per baseline phase probe). During intervention, Ned demonstrated dramatic 48 (0.78 per intervention phase probe), 47 (0.78 per intervention phase probe), and 84 appropriate and variable responses (0.85 per intervention phase probe) for Expressing Wants and Needs, Perspective Taking, and Recognizing and Expressing Emotions, respectively. During maintenance, Ned demonstrated a continued increasing trend for Expressing Wants and Needs, with 116 total appropriate and variable responses (0.38 per maintenance phase probe). Furthermore, appropriate and variable responding was found to increase to 110 (0.53 per maintenance phase probe) and 113 cumulative appropriate and variable responses (0.73 per maintenance phase probe) for Perspective Taking and Recognizing and Expressing Emotions, respectively.

Suzy's cumulative appropriate and variable responses are displayed in Fig. 5. During baseline, Suzy demonstrated 4, 17, and 13 cumulative appropriate and variable responses for Expressing Wants and Needs, Perspective Taking, and Recognizing and Expressing Emotions, respectively. Calculation of appropriate and variable responses per baseline probe yielded 0.04, 0.09, and 0.06 appropriate and variable responses per baseline probe for Expressing Wants and Needs, Perspective Taking, and Recognizing and Expressing Emotions, respectively. Upon termination of the intervention phase, Suzy had demonstrated 74 appropriate and variable responses for Expressing Wants and Needs (0.78 per intervention phase probe), 32 for Perspective Taking (0.30 per intervention phase probe), and 59 for Recognizing and Expressing Emotions (0.92 per intervention phase probe). During the maintenance phase, Suzy demonstrated additional increases for Expressing Wants and Needs, with a total of 124 appropriate and variable responses (0.50 per maintenance phase probe) being observed at the conclusion of the maintenance phase. However, appropriate and variable responding stabilized for Perspective Taking, with 36 appropriate and variable responses observed at the conclusion of the maintenance phase (0.08

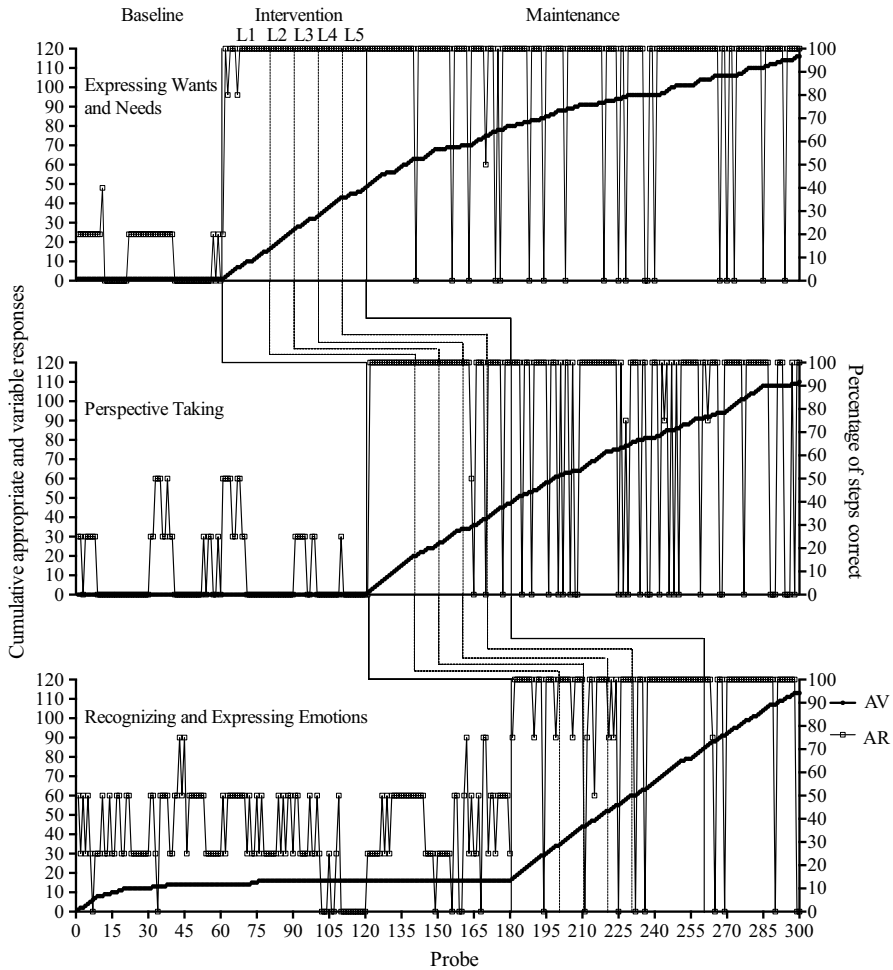


Fig. 4 Cumulative appropriate and variable responses and accurate responding, Ned. AV appropriate and variable response, AR accurate response

per maintenance phase probe). No maintenance data were collected for Recognizing and Expressing Emotions.

Ward demonstrated a low cumulative number across all three target skills during the baseline phase (Fig. 6). Ward demonstrated 10 appropriate and variable responses for Expressing Wants and Needs, 11 for Perspective Taking, and 13 for Recognizing and Expressing Emotions during baseline sessions. Put another way, 0.20, 0.07, and 0.06 appropriate and variable responses per baseline probe were observed for Expressing Wants and Needs, Perspective Taking, and Recognizing and Expressing Emotions, respectively. Ward demonstrated an increase to 88 cumulative appropriate and variable responses for Expressing Wants and Needs (0.70 per intervention phase probe), 31 for Perspective Taking (0.28 per intervention phase

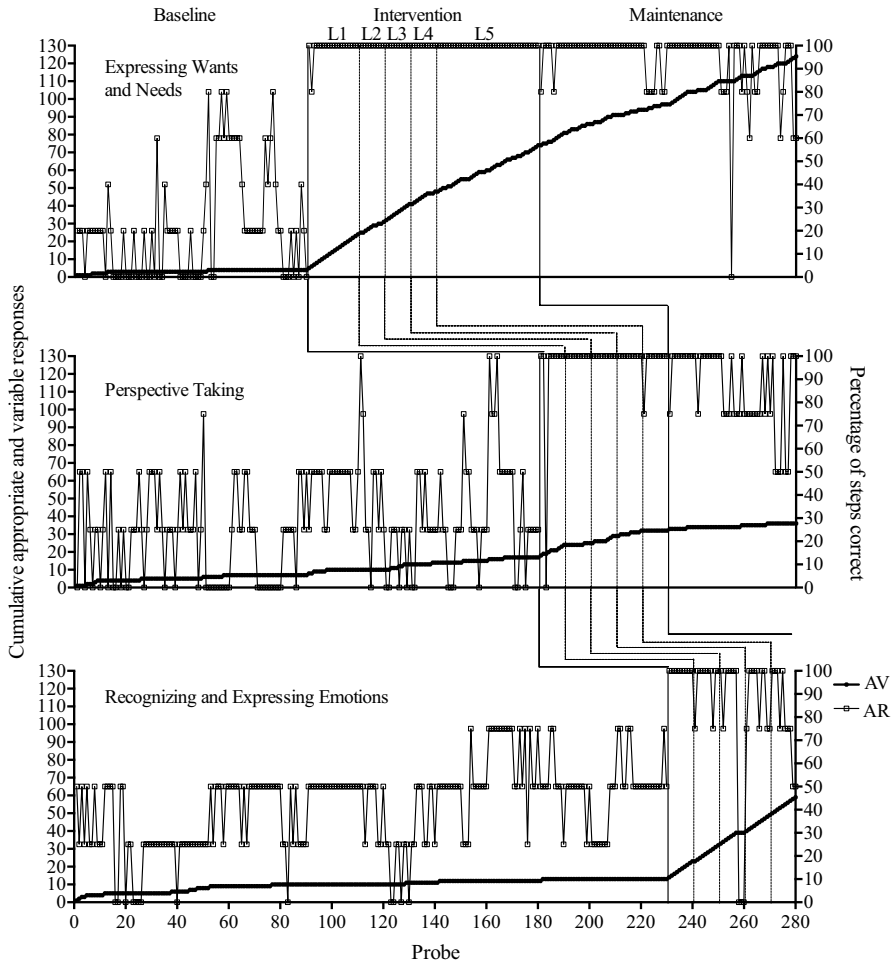


Fig. 5 Cumulative appropriate and variable responses and accurate responding, Suzy. AV appropriate and variable response, AR accurate response

probe), and 117 for Recognizing and Expressing Emotions (0.94 per intervention phase probe) during intervention. During the maintenance phase, Ward’s cumulative number of appropriate and variable responses continued to increase, particularly for Expressing Wants and Needs. At the conclusion of the maintenance phase, Ward had demonstrated a total of 174 appropriate and variable responses for Expressing Wants and Needs with an increase of 86 cumulative appropriate and variable responses (0.43 per maintenance phase probe). Smaller increases in the cumulative number of appropriate and variable responses were observed for Perspective Taking and Recognizing and Expressing Emotions, with increases to 35 (0.11 per maintenance phase probe) and 122 responses (0.45 per maintenance phase probe), respectively.

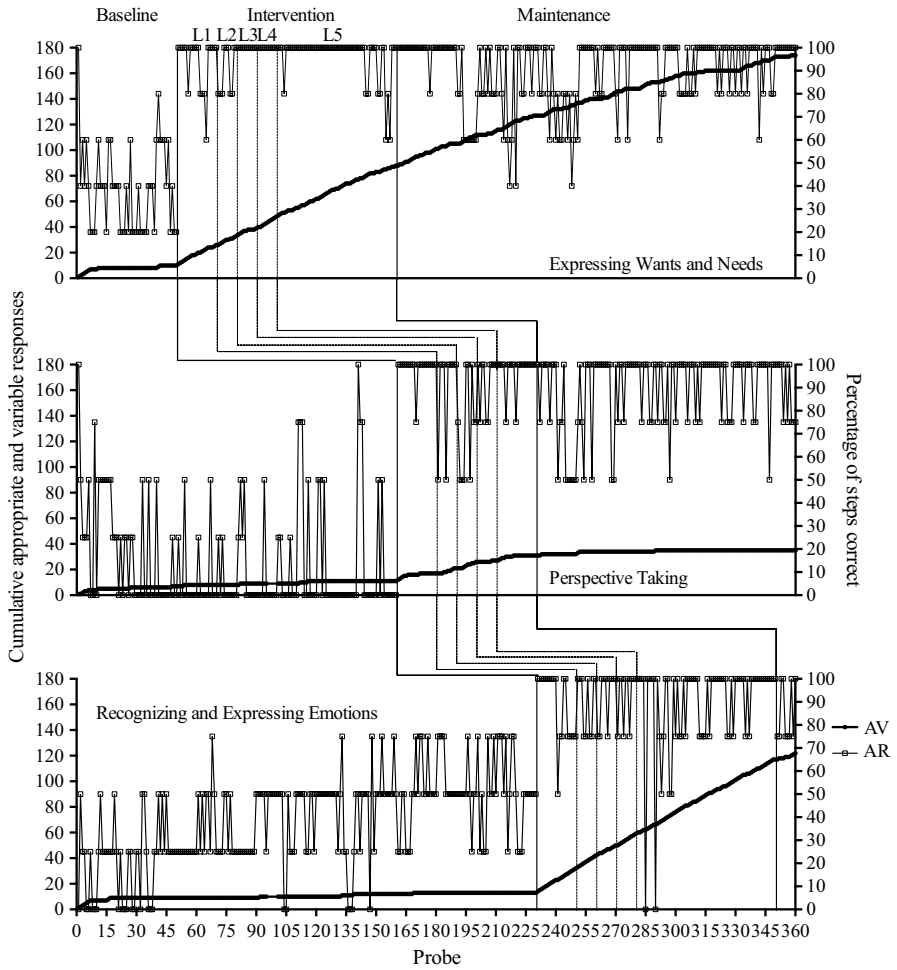


Fig. 6 Cumulative appropriate and variable responses and accurate responding, Ward. AV appropriate and variable response, AR accurate response

Skill Accuracy

The final dependent variable assessed in the current study was the percentage of steps completed correctly for each target skill. During baseline, Ned demonstrated low to moderate levels of skill accuracy across the three target skills, with substantial variability for Perspective Taking and Recognizing and Expressing Emotions (Fig. 4). Introduction of training resulted in rapid increases in level of skill accuracy, with some variability being observed across all three skills. Skill accuracy was observed during maintenance was similar to skill accuracy documented during intervention. Suzy demonstrated low to moderate levels of skill accuracy during baseline, with substantial variability observed across all three target skills (Fig. 5).

Introduction of intervention resulted in increases in level of skill accuracy. Maintenance phase data indicated increases in level over baseline levels, with increased variability compared to intervention phase data. Skill accuracy for Ward was low to moderate during baseline probes (Fig. 6). During intervention, improvements in level of skill accuracy were noted. Similar to Ned, levels of skill accuracy during maintenance were similar to those observed during intervention phases.

Discussion

Although previous research has found interventions incorporating lag schedules of reinforcement to be effective strategies for increasing appropriate and variable responding (e.g., Baruni et al. 2014; Lee et al. 2002; Radley et al. 2017), the generalizability and practicality of procedures to school settings may be considered limited due to factors related to intensity of intervention, setting, and lack of manualized procedures (Kasari and Smith 2013). As such, the purpose of the present study was to extend the current literature on lag schedules of reinforcement through a manualized social skills program modified to incorporate lag schedules within a school setting. Specifically, the current study sought to increase appropriate and variable responding and skill accuracy of three children with ASD. The results of the current study demonstrate that lag schedules of reinforcement may feasibly be incorporated into school-based social skills training as a means to increase the number of appropriate and variable responses demonstrated by children with ASD. Additionally, results indicated maintenance of appropriate and variable responding above baseline levels following termination of instruction.

The findings of the current study are important given that all procedures were implemented within a school setting. Whereas lag schedules have been found to be effective in increasing appropriate and variable responding, studies have often been conducted in clinic settings (e.g., Broadhead et al. 2016; Contreras and Betz 2016; Radley et al. 2017). School-based social skills training is likely to have several advantages over training in other settings, related to the fact that schools represent naturalistic environments where newly learned skills can be readily practiced (e.g., Bellini et al. 2007; Kasari and Smith 2013). This advantage may, in part, explain differences in maintenance of improvements between the current study and Radley and colleagues (2017), who utilized a social skills curriculum modified to incorporate lag schedules in a clinic setting. Whereas the current study found high levels of maintenance of both appropriate and variable responding and skill accuracy, Radley and colleagues found appropriate and variable responding returned to baseline levels during maintenance. Additionally, the findings of improvements during intervention and maintenance phases are particularly noteworthy given the intensity with which the intervention was implemented. Whereas Radley and colleagues utilized a modified social skills curriculum incorporating lag schedules during social skills training during 2-h sessions conducted twice-weekly, the present study found one 30-min social skills training session per week over an approximately 8 weeks to result in increased appropriate and variable responding—a level of intensity that is more

representative of typical social skills training within a school setting (e.g., Bellini et al. 2007).

Limitations and Directions for Future Research

In evaluating the results of the present study, several limitations should be considered. First, the design of the current study did not allow for determination of whether training alone would result in increased variability, as in Radley and colleagues (2017) study. As such, it is possible that the observed improvements in appropriate and variable responding were due to training alone. Although previous researchers have found training alone to result in minimal changes in appropriate and variable responding, future researchers should assess the effect of training in isolation prior to incorporation of contingencies targeting appropriate and variable responding. Relatedly, future researchers should consider collecting additional data regarding social validity of intervention procedures, such as ratings of tone and prosody of responses. Second, maintenance data were not collected for Suzy for Recognizing and Expressing Emotions due to time constraints and school absences. Thus, it is unknown if Suzy maintained appropriate and variable responding following removal of the lag schedules of reinforcement. Given limited maintenance found in previous research (e.g., Bellini et al. 2007; Radley et al. 2017), future researchers should determine whether skill maintenance is observed for all target skills.

Third, results of the study indicated a sharp increase in appropriate and variable responses following implementation of intervention. However, no data were collected regarding generalization of appropriate and variable responding. As such, participants may have provided responses that met lag requirements during probes (e.g., changing from “I am happy because...” to “I am sad because...” in response to the probe “How are you feeling today?”), but persisted in restricted responding under more naturalistic settings (e.g., with peers, teachers). Given that the current study did not assess appropriate and variable responding in generalized contexts, future researchers should plan for the collection of generalization data. Further, researchers may consider allowing for longer intervals between training and data collection in generalizations settings (e.g., 24 h) as a means of increasing confidence in the observed findings. Fourth, no phase change criteria were specified in the current study. Although increases in lag schedule requirements were based on meeting a prespecified criterion, future researchers may consider setting a similar criterion for changes from intervention to maintenance phases. Fifth, it was possible for participants to vary responding on both steps three and five of Perspective Taking. However, for the purposes of the current study, appropriate and variable responding was assessed based only on the fifth step (i.e., offer assistance). As such, it is possible that some variable responses were not recorded, and future researchers may consider assessing variability across both steps of the skill.

Sixth, researchers did not provide participants with a specific rule regarding the lag schedule as in Radley and colleagues (2017) study. However, the feedback provided to participants may have served as an incomplete rule, or a statement that has implied consequences (Falcomata et al. 2008; Malott et al. 1997). The potential for

feedback to serve as an incomplete rule may also be evidenced by the fact that participants demonstrated immediate and high rates of novel responding that exceeded the lag schedule requirement—indicating that behavior was insensitive to the different lag values. As the relative contribution of this feedback element to the increased appropriate and variable responses observed in the current study cannot be determined, it is subsequently impossible to determine whether this element, the lag schedules, or the combination of the two procedures was essential to promote behavior change. Future researchers should consider omitting explicit feedback, rules, or instructions in order to better evaluate the effect of lag schedules of reinforcement. Finally, although the current study provides a model for use of social skills training incorporating lag schedules within a school setting, it must be noted that intervention procedures were implemented by a doctoral student in school psychology with substantial experience in social skills training. As such, future researchers should evaluate the effectiveness and feasibility of social skills training incorporating lag schedules of reinforcement when facilitated by school personnel (e.g., school psychologists, special education teachers, paraprofessionals).

Compliance with Ethical Standards

Conflict of interest All authors of the study report no conflict of interest.

Ethical Approval All procedures performed in the current study were in accordance with the ethical standards of the institution and the national research committee and with the 1964 Helsinki Declaration and its later amendments.

Informed Consent Informed consent and assent were obtained for all individual participants included in the study.

Appendix A

Treatment Integrity Checklist

Skill:

Date:

Observer:

Lag schedule:

Record if components were conducted as indicated (Yes) or not conducted as indicated (No) during each group instruction session; or if the day's session did not require a particular component (N/A).

Social Skills Training components	YES	NO	N/A
1. Determine lag schedule based on decision rules			
2. Pick up participants from their classrooms			
3. Probe target baseline skills; no contingent reinforcement			
4. Probe target maintenance skills; no contingent reinforcement			
5. Have materials ready and place in front of group			
6. Greet group, review rules and daily schedule			
7. Review purpose of session			
8. View animated video and video models of peers			
9. Model three variations of the target skill as indicated			
10. Role play skill with participants. Allow each participant 3-5 opportunities to respond.			
11. Provide performance feedback as indicated for correct and incorrect skill use during role play			
12. View animated comic book			
13. Conduct probes of skills individually with students			
14. Provide tokens in accordance with lag schedule following accurate and variable responses			
15. Provide error correction as indicated following accurate and variable responses			
16. Return participants to their classrooms			

References

- American Psychiatric Association. (2013). *DSM-5. Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: American Psychiatric Association.
- Baruni, R. R., Rapp, J. T., Lipe, S. L., & Novotny, M. A. (2014). Using lag schedules to increase toy play variability for children with intellectual disabilities. *Behavioral Interventions*, 29, 21–35.

- Bellini, S., & Hopf, A. (2007). The development of the autism social skills profile: A preliminary analysis of psychometric properties. *Focus on Autism and Other Developmental Disabilities, 22*, 80–87.
- Bellini, S., Peters, J., Benner, L., & Hopf, A. (2007). A meta-analysis of school-based social skills interventions for children with autism spectrum disorders. *Remedial and Special Education, 28*, 153–162.
- Betz, A. M., Higbee, T. S., Kelley, K. N., Sellers, T. P., & Pollard, J. S. (2011). Increasing response variability of mand frames with script training and extinction. *Journal of Applied Behavior Analysis, 44*, 357–362.
- Broadhead, M. T., Higbee, T. S., Gerenscer, K. R., & Akers, J. S. (2016). The use of a discrimination training procedure to teach man variability to children with autism. *Journal of Applied Behavior Analysis, 49*, 34–48.
- Contreras, B. P., & Betz, A. M. (2016). Using lag schedules to strengthen the intraverbal repertoires of children with autism. *Journal of Applied Behavior Analysis, 49*, 3–16.
- Creak, M. (1972). Reflections on communication and autistic children. *Journal of Autism and Childhood Schizophrenia, 2*, 1–8.
- Dingfelder, H. E., & Mandell, D. S. (2011). Bridging the research-to-practice gap in autism intervention: An application of diffusion of innovation theory. *Journal of Autism and Developmental Disorders, 41*, 597–609.
- Falcomata, T. S., Northup, J. A., Dutt, A., Stricker, J. M., Vinquist, K. M., & Engebretson, B. J. (2008). A preliminary analysis of instructional control in the maintenance of appropriate behavior. *Journal of Applied Behavior Analysis, 41*, 429–434.
- Hess, K. L., Morrier, M. J., Heflin, J., & Ivey, M. L. (2008). Autism treatment survey: Services received by children with autism spectrum disorders in public school classrooms. *Journal of Autism and Developmental Disorders, 38*, 961–971.
- Jenson, W. R., Bowen, J., Clark, E., Block, H. M., Gabrielsen, T., Hood, J. A., et al. (2011). *Superheroes social skills*. Eugene, OR: Pacific Northwest.
- Kasari, C., & Smith, T. (2013). Interventions in schools for children with autism spectrum disorder: Methods and recommendations. *Autism, 17*, 254–267.
- Lane, J. D., Gast, D. L., Shepley, C., & Ledford, J. R. (2015). Including social opportunities during small group instruction of preschool children with social-communication delays. *Journal of Early Intervention, 37*, 3–22.
- Lee, R., McComas, J. J., & Jawor, J. (2002). The effects of differential and lag reinforcement schedules on varied verbal responding by individuals with autism. *Journal of Applied Behavior Analysis, 35*, 391–402.
- Lee, R., & Sturmey, P. (2006). The effects of lag schedules and preferred materials on variable responding in students with autism. *Journal of Autism and Developmental Disorders, 36*, 421–428.
- Lepper, T. L., Devine, B., & Petursdottir, A. I. (2016). Application of lag contingency to reduce perseveration on circumscribed interests. *Developmental Neurorehabilitation*. <https://doi.org/10.3109/17518423.2016.1152612>.
- Malott, R. W., Whaley, D. L., & Malott, M. E. (1997). Analogs to reinforcement part I. In R. W. Matlott, D. L. Whaley, & M. E. Malott (Eds.), *Elementary principles of behavior* (3rd ed., pp. 332–347). Upper Saddle River, NJ: Prentice Hall.
- Mercier, C., Mottron, L., & Belleville, S. (2000). A psychosocial study on restricted interests in high functioning persons with pervasive developmental disorders. *Autism, 4*, 406–425.
- O’Handley, R. D., Ford, W. B., Radley, K. C., Helbig, K. A., & Wimberly, J. K. (2016). Social skills training for adolescents with intellectual disabilities: A school-based evaluation. *Behavior Modification, 40*, 541–567.
- Parsonson, B. S., & Baer, D. M. (1978). Training generalized improvisation of tools by preschool children. *Journal of Applied Behavior Analysis, 11*, 363–380.
- Radley, K. C., Dart, E. H., Moore, J. W., Battaglia, A. A., & LaBrot, Z. C. (2017). Use of lag schedules to promote accurate variability of social skills children with autism spectrum disorder. *Behavior Modification, 41*, 84–112.
- Radley, K. C., Ford, W. B., McHugh, M. B., Dadakhodjaeva, K., O’Handley, R. D., Battaglia, A. A., et al. (2015). Brief report: Use of Superheroes Social Skills to promote accurate social skill use in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 45*, 3048–3054.

- Rao, P. A., Beidel, D. C., & Murray, M. J. (2008). Social skills interventions for children with Asperger's syndrome or high-functioning autism: A review and recommendations. *Journal of Autism and Developmental Disorders*, *38*, 353–361.
- Reichow, B., & Volkmar, F. R. (2010). Social skills interventions for individuals with autism: Evaluation of evidence-based practices with a best evidence synthesis framework. *Journal of Autism and Developmental Disorders*, *40*, 149–166.
- Sellers, T. P. (2011). *Increasing mand variability in preschoolers with autism* (Unpublished doctoral dissertation). Utah State University, Logan.
- Susa, C., & Schlinger, H. D. (2012). Using a lag schedule to increase variability of verbal responding in an individual with autism. *The Analysis of Verbal Behavior*, *28*, 125–130.
- Wang, P., & Spillane, A. (2009). Evidence-based social skills interventions for children with autism: A meta-analysis. *Education and Treatment of Children*, *44*, 318–342.
- Whalon, K. J., Conroy, M. A., Martinez, J. R., & Werch, B. L. (2015). School-based peer-related social competence interventions for children with autism spectrum disorder: A meta-analysis and descriptive review of single case research design studies. *Journal of Autism and Developmental Disorders*, *45*, 1513–1531.
- Wolfe, K., Slocum, T. A., & Kunnavatana, S. S. (2014). Promoting behavioral variability in individuals with autism spectrum disorders: A literature review. *Focus on Autism and Other Developmental Disabilities*, *29*, 180–190.