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THE EFFECTIVENESS OF AND PRESCHOOLERS' PREFERENCES FOR VARIATIONS OF MULTIPLE-SCHEDULE ARRANGEMENTS

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Multiple schedules of reinforcement have been used to teach children to recruit attention only when it is available, thereby minimizing disruptive requesting during instructional activities. This procedure involves alternating periods of continuous reinforcement (CRF) with periods of extinction and correlating each period with a distinct and continuous discriminative stimulus. The present study evaluated the effectiveness of and children's preferences for multiple schedules in which (a) two different stimuli, one correlated with reinforcement (S+) and another correlated with extinction (S−), were presented; (b) only an S+ was presented (i.e., no stimulus was correlated with extinction), and (c) neither an S+ nor an S− was presented (i.e., a mixed schedule). S+/S− and S+ arrangements were similarly effective for 7 children, but 3 preferred the S+/S− condition and 4 preferred the S+ condition. Correlational analyses suggested that children who responded more effectively given the S− (discrimination indexes were relatively high) preferred the S+/S− condition, whereas children who responded less effectively given the S− preferred the S+ condition. The implications of these findings for arranging multiple schedules for social responses are discussed.

DESCRIPTORS: concurrent-chains arrangement, multiple schedule, mixed schedule, preference assessment, preschoolers

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Early childhood environments provide an opportunity not only to teach social and academic skills to young children but also to enrich early educational experiences with preferred events, materials, and social interactions. Ideally, incorporating children's preferences into the design of educational environments will result in children enjoying and ultimately seeking learning opportunities. Several studies have been designed to measure young children's preferences for structured learning opportunities and to enhance the value of these activities relative to exclusively play-based activities (e.g., Hanley, Tiger, Ingvarsson, & Cammilleri, in press; Heal & Hanley, in press).

For instance, Hanley et al. (in press) designed an instructional area, termed the *instructional zone,* in which teachers provided direct instruction to individual children on concepts selected from individualized curricula. This zone was made available among eight other play activities during free-choice periods (i.e., children could attend any of the nine zones). Initially, children rarely attended the instructional zone. Following the addition of an embedded reinforcement contingency (i.e., teacher attention, edible items or trinkets, and iconic decorations were included in the instructional zone) children's attendance at the instructional zone increased to the point that it was preferred more than most play-oriented activities.

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As attendance in this zone increased, novel challenges emerged when teachers attempted to deliver individualized instruction to small groups of children simultaneously. Effective small-group interaction involved alternating instruction among members of the group, such that while 1 child was instructed by the teacher, the other children worked independently or played quietly. Thus, children were required to discriminate times when it was appropriate to recruit their teacher's attention or assistance. Learning opportunities were disrupted by ill-timed requests for teacher attention or assistance by children who were not the focus of instruction at that particular moment.

Tiger and Hanley (2004) evaluated one procedure to minimize disruptions during these teaching situations. In this study, teachers wore colored floral leis to signal the availability of their attention to individual children. The teacher wore a red floral lei when attention was available to one child, a blue floral lei when attention was available to the other child, and a white floral lei when attention was not available to either child. This procedure was essentially a multiple schedule in that two schedules of reinforcement (i.e., reinforcement and extinction) were alternated on a time-based schedule, and each was correlated with a discriminative stimulus. This procedure resulted in decreased requesting during extinction periods and maintenance of requesting during personal reinforcement periods for 3 preschool-aged children.

Although it is described here for use during teaching situations, this type of multiple-schedule procedure has been used in the treatment of severe problem behavior (e.g., Fisher, Kuhn, & Thompson, 1998; Hagopian, Toole, Long, Bowman, & Lieving, 2004; Hanley, Iwata, & Thompson, 2001; Neidert, Iwata, & Dozier, 2005) and in teaching verbal skills to children with autism (Sidener, Shabani, Carr, & Roland, in press). One similarity that exists among these studies is that all involved the presentation of both an S+ (a discriminative stimulus correlated with reinforcement) and an S− (a discriminative stimulus correlated with extinction). The consistent use of an overt stimulus to signal extinction is curious in light of research by Mulvaney, Dinsmoor, Jwaideh, and Hughes (1974) and Terrace (1971) suggesting that S− stimuli may be nonpreferred or even aversive.

Mulvaney et al. (1974) assessed pigeons' preferences for multiple-schedule conditions in which extinction-correlated stimuli were present or absent. In this study, reinforcement and extinction contingencies for key pecking alternated according to a time-based schedule, in which the response key was illuminated white during both periods. Pecking a second key, called an observing response, temporarily changed the keylight to either green, if a reinforcement component was arranged, or red, if an extinction component was arranged. In essence, the observing response switched the arrangement from a mixed schedule in which there were no discriminative stimuli associated with the two alternating schedules to a multiple schedule in which there were discriminative stimuli associated with both schedules. Pigeons then experienced a concurrent-chains arrangement in which a selection response provided access to one of two conditions. In one condition, an observing response resulted in the presentation of a green light during reinforcement components and a red light during extinction components. In the other condition, the observing response resulted in only the presentation of the green light (i.e., no stimulus change occurred during extinction periods). Although the observing response produced no changes to the operating schedules of reinforcement, pigeons predominantly selected the latter arrangement in which explicit extinction-correlated stimuli were not presented.

Terrace (1971) evaluated the effects of S− presentation in an experiment in which pigeons could turn off the S−. In this study, pigeons' learning histories were experimentally programmed in a multiple-schedule arrangement. One group of pigeons was taught an S+/S− discrimination without errors, and a second group was taught the same discrimination with errors; pigeons rarely responded during the S− with errorless training and responded often during the S− with error-prone training. The efficacy of S− termination as a reinforcer was then evaluated with these pigeons (i.e., the light associated with extinction could be turned off during extinction periods). Only the pigeons trained with errors were sensitive to this reinforcer. In sum, the S− served as an aversive stimulus only for pigeons with a history of experiencing extinction in the presence of the S−, whereas the S− remained a neutral stimulus for pigeons without a history of experiencing extinction.

The finding that extinction-correlated stimuli may have aversive properties has implications for the use of multiple-schedule arrangements during instructional situations. If children avoid learning contexts due to the presentation of extinction-correlated stimuli, the use of multiple schedules would ultimately be counterproductive. Although extinction conditions cannot be avoided (i.e., attention cannot be simultaneously available to all children), explicitly signaling these conditions can be avoided. In other words, multiple schedules could be arranged in which extinction periods are not explicitly signaled (as in Mulvaney et al., 1974). For instance, a continuous signal could be provided during reinforcement periods, and the absence of this signal could serve as a discriminative stimulus during extinction periods. Thus the use of an explicit S− may be avoided. However, the effectiveness of this type of arrangement has not yet been systematically evaluated with children.

The purpose of the present study was twofold. The first purpose was to evaluate the relative effectiveness of two variations of multiple-schedule arrangements for promoting discriminated social responding with preschool children during teaching situations. The first variation involved presenting continuous discriminative stimuli during both reinforcement and extinction periods (hereafter referred to as the S+/S− arrangement; based on the procedures of Tiger & Hanley, 2004). The second variation involved presenting a continuous discriminative stimulus during reinforcement periods but no such stimulus during extinction periods (hereafter referred to as the S+ arrangement). These variations were compared to a control condition that involved the presentation of a single uncorrelated stimulus during both reinforcement and extinction components (hereafter referred to as the mixed arrangement). The second purpose was to assess children's preferences for these multiple-schedule variations to assess the potential deleterious effects of presenting extinction-correlated stimuli.

METHOD

Participants and Setting

Seven participants were selected from a full-day, university-based inclusive preschool serving typically and atypically developing children from 2.5 to 5.5 years old. Participants were selected who had (a) a well-developed repertoire of appropriate requests, (b) the ability to follow multistep instructions, and (c) availability at scheduled research times. At the start of the analysis, Emma was 3 years 9 months old, Joe was 3 years 10 months old, Josh was 4 years 7 months old, Carl was 4 years 8 months old, Ana was 4 years 10 months old, John was 4 years 11 months old, and Chuck was 5 years 7 months old. All children were typically developing, except Carl, who had been diagnosed with Asperger syndrome. Sessions were conducted in a room (5 m by 5 m) equipped with a one-way observation window. The room was designed to simulate classroom periods in which a teacher provided individual instruction to children (i.e., children were provided with developmentally appropriate materials while seated at a small table across from the experimenter).

Response Measurement

Each session was conducted using a modified concurrent-chains procedure (Hanley, Piazza, Fisher, Contrucci, & Maglieri, 1997). That is, each session was divided into two parts called initial and terminal links. During the initial links, the child approached the session room door, on which there were three cards (10 cm by 10 cm) of different colors. Each card was correlated with a different multiple-schedule arrangement in the terminal links of the chain. Children's card selections, defined as handing one of the three cards to the experimenter, were scored by circling the selected card on a pre-coded data sheet. The initial link was completed after the child selected a card and entered the session room. Card selections in the initial link were our measure of preference for the arrangements in the terminal links. During the 3-min terminal links, children's social approaches were scored as any vocal (e.g., saying, "Look at what I built") or nonvocal (e.g., waving a hand while making eye contact) behavior directed towards the experimenter. A new occurrence was scored following a 2-s pause between responses. Attention delivery by the adult was recorded as any vocal (e.g., saying, "That looks great") or nonvocal (e.g., giving a high five) behavior directed towards the child. In this regard, the concurrent-chains procedure separated a response in the initial link from the reinforcers that maintained responding in the terminal link. In essence, this procedure allowed us to measure the relative effectiveness of three multiple-schedule arrangements in the terminal links of the chain as well as children's preferences for each in the initial links of the chain.

Interobserver Agreement

Interobserver agreement was assessed separately for the initial and terminal links by having a second observer simultaneously but independently score children's responding. Card-selection agreement was defined as both observers circling the same card in each initial link. Card selection was never scored in disagreement. Agreement for social approach and attention delivery was determined by partitioning terminal links into 10-s intervals and comparing data collectors' records on an interval-by-interval basis. Within each interval, the smaller number of responses was divided by the larger number. These quotients were then multiplied by 100% and averaged across intervals. Observers were trained to be at least 85% reliable prior to including their data in the study. Agreement was collected during 58% of terminal links across participants (range, 30% to 95%). Agreement on social approaches averaged 95% for Emma (range, 80% to 100%), 94% for Joe (range, 83% to 100%), 90% for Ana (range, 76% to 100%), 89% for John (range, 68% to 100%), 96% for Josh (range, 82% to 100%), 97% for Chuck (range, 84% to 100%), and 85% for Carl (range, 63% to 100%). Agreement on attention delivery averaged 97% for Emma (range, 90% to 100%), 97% for Joe (range, 84% to 100%), 95% for Ana (range, 85% to 100%), 95% for John (range, 66% to 100%), 99% for Josh (range, 84% to 100%), 99% for Chuck (range, 90% to 100%), and 94% for Carl (range, 80% to 100%).

Procedure

Each session consisted of one initial-link response opportunity in which a child stood outside the session room door and selected one of three different-colored cards (a red and blue card correlated with the red and blue floral leis worn by the experimenter during the S+/S− terminal link, a red card correlated with the red lei worn by the experimenter during the S+ terminal link, and a white card correlated with the white lei worn by the experimenter during the mixed terminal link), and one terminal-link experience in which a participant sat across from an experimenter in the simulated classroom. After the child entered the session room, the experimenter held up the initial-link card and the correlated discriminative stimuli (i.e., floral leis) and said, "[Child's name], you handed me the [red and blue, red, or white] card, so I am going to wear the [red and blue, red, or white] lei." The experimenter then described the contingencies associated with the floral lei to be presented in the current session. For the S+/S− link, the experimenter said, "When I am wearing the red lei, it is your time, I can answer your questions and talk to you. When I am wearing the blue lei, it is my time, I cannot answer your questions or talk to you." For the S+ link, the experimenter said, "When I am wearing the red lei, it is your time, I can answer your questions and talk to you." During the mixed link, the experimenter said, "When I am wearing the white lei, sometimes it is your time, when I can answer your questions and talk to you, and sometimes it is my time, when I cannot answer your questions and talk to you." The child was then prompted to respond in the presence of each lei and experience the programmed contingency.

During reinforcement periods, the experimenter diverted his attention from the child (e.g., looked down or away) except when providing a brief statement of attention contingent on each social approach by the child. During extinction, the experimenter also diverted his attention but did not respond to any social approach by the child. Reinforcement and extinction components occurred three times per session, in a random alternation, for 15, 30, and 45 s each, yielding a total of 90 s of reinforcement and 90 s of extinction per session. Components were randomly alternated to minimize the potential that a temporal discrimination would develop (something that would be highly unlikely under typical classroom conditions). Further, individual components were brief to minimize the likelihood of the participant discriminating the operating contingencies independent of schedule-correlated stimuli (e.g., Tiger & Hanley, 2005). The order of these components was randomly determined prior to each session block, but was held constant across each session within a session block (i.e., the pattern of reinforcement and extinction components was identical across exposure to the three terminal links). Thus, the only difference between terminal links was the presentation of discriminative stimuli. During the S+/S− links, the experimenter continuously wore a red lei during reinforcement components and a blue lei during extinction. During the S+ link, the experimenter continuously wore a red lei during periods of reinforcement but no lei was worn during extinction components. During the mixed link, the experimenter wore a white lei during both reinforcement and extinction components; thus, the component changes were not signaled to the child.

Each participant experienced two distinct phases during their evaluation. The first was the forced-choice phase, which was designed to assess the relative effectiveness of the S+/S−, S+, and mixed arrangements for (a) reducing responding during extinction periods and (b) maintaining responding during reinforcement periods. During this phase's initial links, the experimenter vocally prompted the child to select specific cards in a random and counterbalanced order, with one or two exposures to each terminal link daily (i.e., a total of three or six sessions were conducted daily). This procedure served two purposes: (a) It allowed a comparison of the three conditions in a multielement design, and (b) it exposed participants to the correlations between cards in the initial links and the arrangements that operated in the terminal links. This phase continued until participants engaged in discriminated social approaches in at least one of the terminal links. Discriminated responding was defined as elevated responding during reinforcement components relative to extinction components for six consecutive sessions.

The second was the free-choice phase, which was designed to assess children's preferences for the multiple schedules arranged in the terminal links. During the initial links in this second phase, the participant was told, "Choose the card you like." Children then experienced the terminal link that was correlated with their selected card. Terminal-link contingencies were identical to those described during the initial phase. A terminal link was considered preferred if it met one of two criteria: (a) It had been selected on six consecutive opportunities, or (b) it had been selected on six opportunities more than either of the other two options. After either of these preference criteria had been met, the preferred arrangement was removed from the array (e.g., the card associated with the preferred link was removed), such that a preference could then be determined between the remaining two arrangements. The same preference criteria were applied again to determine a preference hierarchy for the remaining arrangements; the evaluation was then terminated. If 30 sessions were conducted and preference criteria were not met, the evaluation was terminated and a preference hierarchy was determined based on the relative number of selections of each arrangement.

Treatment Integrity

We determined the integrity of implementation of the independent variable by analyzing the correspondence between the number of social approaches emitted and the number of instances of attention delivery within reinforcement and extinction components of the multiple-schedule (S+/S−, S+) and mixed-schedule arrangements (Tiger & Hanley, 2005). During reinforcement components, the smaller of the two numbers were divided by the larger number. During extinction components, this fraction was subtracted from one. Components with zero approaches and zero instances of attention were given a score of one. All measures were then multiplied by 100% to yield treatment integrity scores. For instance, if four social approaches and three instances of attention delivery were scored during a reinforcement component, this component received an integrity score of 75%. However, if the same number of each response was scored during an extinction component, this component received an integrity score of 25%. These percentages were then averaged together to yield treatment integrity scores of 97% for Ana, 94% for Josh, 99% for John, 95% for Joe, 96% for Emma, 97% for Chuck, and 93% for Carl.

RESULTS

Data for the 7 participants are presented in Figures 1 and 2. Individual participant's data are shown in columns. Under the S+/S− arrangement, Ana responded at high rates during reinforcement components (M = 9.8 responses per minute) and at low rates during extinction components (M = 1.0) across both the forced- and free-choice phases. She responded similarly under the S+ arrangement (Ms = 8.0 during reinforcement and 1.6 during extinction components). These patterns may be contrasted with those observed under the mixed arrangement, in which response rates under reinforcement (M = 5.4) and extinction (M = 2.8) were more similar. When Ana had the opportunity to select from the three arrangements, she demonstrated a preference for the S+/S− arrangement by selecting it on the first six consecutive sessions. When this option was restricted, she selected the S+ arrangement on the next six consecutive opportunities. She never selected the mixed arrangement during her preference assessment.

Josh emitted similar response patterns during the S+/S− (Ms = 9.4 during reinforcement and 0.6 during extinction) and the S+ arrangements (Ms = 8.7 during reinforcement and 0.4 during extinction). Again more indiscriminate patterns were observed under the mixed arrangement (Ms = 2.9 during reinforcement and 1.4 during extinction). When allowed to choose, Josh demonstrated a preference for the

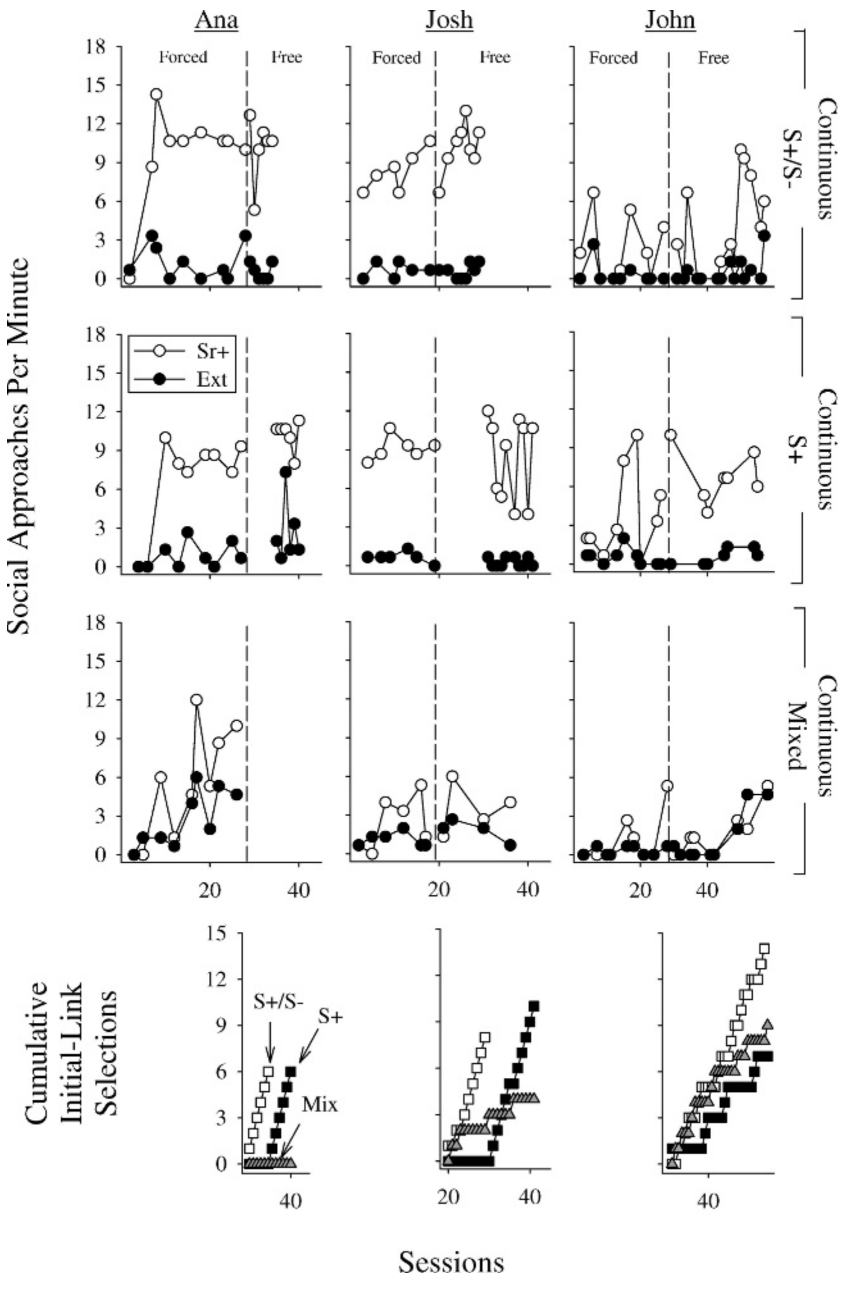

Figure 1. Responding during reinforcement (open circles) and extinction (closed circles) components of S+/S−, S+, and mixed terminal links (first, second, and third rows of panels) and initial-link selections of the preferences assessment (bottom row of panels) for Ana, Josh, and John. Separation of the two data paths is considered discriminated and a desirable pattern of responding, while overlap is considered indiscriminate responding. The bottom panel for each participant depicts the cumulative initial-link selections during the preference assessment (free-choice phase). The point at which a data path stops represents the restriction of that link (i.e., a preference had been identified and that option was no longer presented during the initial links).

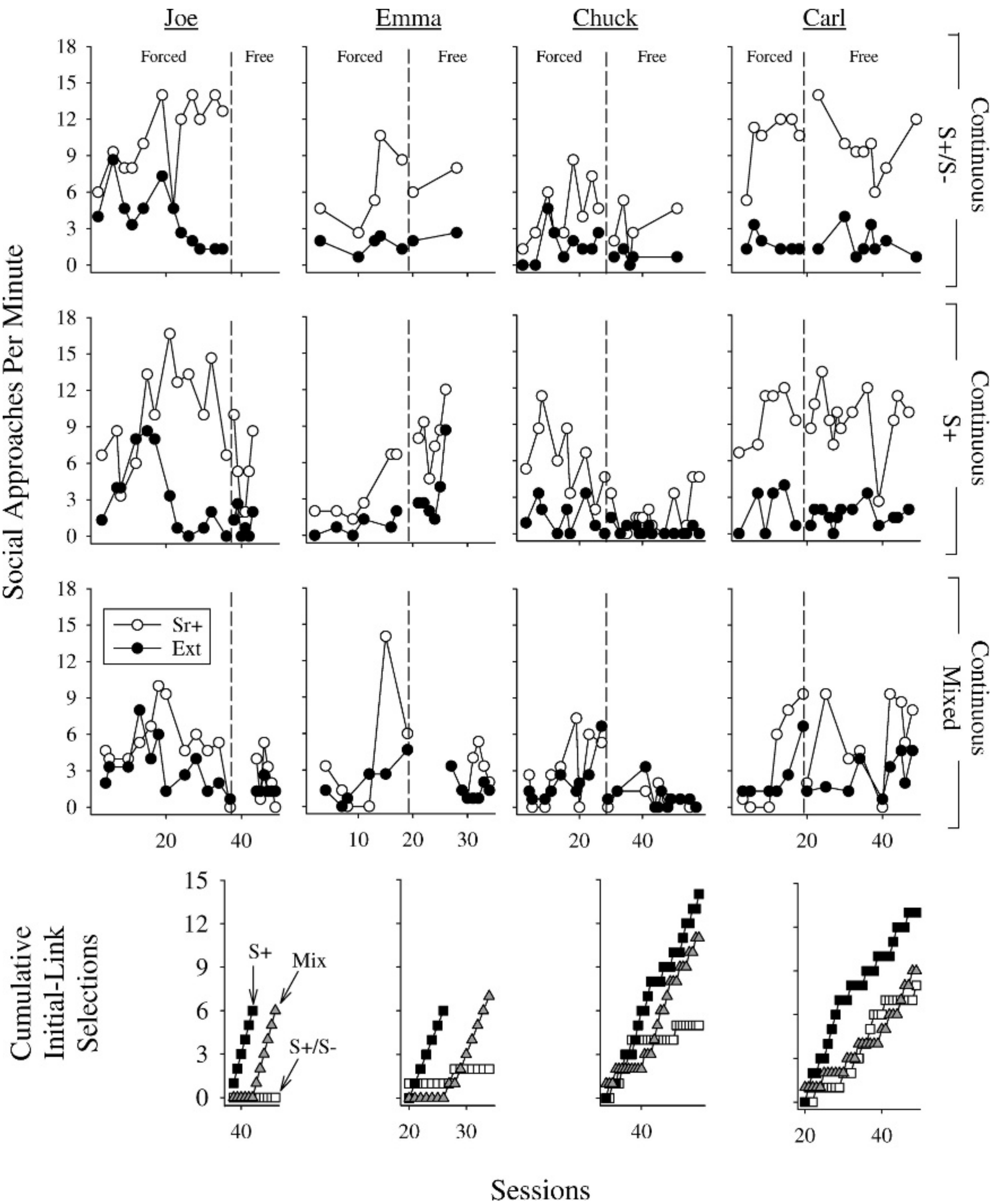

Figure 2. Responding during reinforcement (open circles) and extinction (closed circles) components of S+/S−, S+, and mixed terminal links (first, second, and third rows of panels) and initial-link selections of the preference assessment (bottom row of panels) for Joe, Emma, Chuck, and Carl. Terminal-link data for one session (Emma, Session 4, S+/S− condition) were lost due to a computer error.

S+/S− arrangement by selecting it on six consecutive opportunities. When this option was restricted, he eventually selected the S+ arrangement on six consecutive opportunities.

John engaged in variable responding during reinforcement components of the S+/S− arrangement (*M* = 3.2) but consistently low responding during extinction components (*M* = 0.5). His responding was more stable during reinforcement components of the S+ arrangement (*M* = 5.1) and again was consistently low during extinction components (*M* = 0.5). Responding was low during both reinforcement (*M* = 1.2) and extinction (*M* = 0.8) components of the mixed arrangement. When given a choice among the three arrangements, he engaged in variable selections, but selected the S+/S− arrangement on six opportunities more than the other arrangements on the 29th session of the preference assessment. This option was restricted for the final session before meeting the 30-session criteria to terminate the assessment. During the preference assessment, John selected the mixed arrangement on nine opportunities and the S+ arrangement on seven.

Joe initially engaged in indiscriminate responding during all three arrangements. However after continued exposure, responding became elevated during reinforcement components (*M* = 10.4) and decreased during extinction components (*M* = 3.8) of the S+/S− arrangement. A similar pattern emerged under the S+ arrangement (*M*s = 8.6 during reinforcement and 2.6 during extinction components), although overall responding decreased towards the end of the assessment. Responding remained similar during reinforcement (*M* = 4.4) and extinction (*M* = 2.7) components of the mixed arrangement. When given a choice among the three arrangements, Joe selected the S+ arrangement on the first six opportunities. When this option was restricted, Joe then selected the mixed arrangement on the next six consecutive opportunities. Joe did not select the S+/S− during the preference assessment.

Emma engaged in elevated levels of responding during reinforcement components (*M* = 6.6) and decreased levels of responding during extinction components (*M* = 1.9) of the S+/S− arrangement. Her responding was consistently higher during reinforcement components (*M* = 5.9) than extinction components (*M* = 2.2) of the S+ arrangement as well. Her responding was more similar during reinforcement (*M* = 3.4) and extinction (*M* = 1.7) components of the mixed arrangement. When provided the opportunity to choose arrangements, Emma selected the S+ arrangement on six consecutive opportunities. When this option was restricted, she then selected the mixed arrangement on six consecutive opportunities. She selected the S+/S− on only two opportunities during her assessment.

Chuck engaged in variable rates of responding during reinforcement components (*M* = 3.9), but consistently lower rates during extinction components (*M* = 1.3) of the S+/S− arrangement. During S+ conditions, Chuck initially engaged in high levels of responding that decreased towards the end of the assessment. However, when he did respond, rates during reinforcement components (*M* = 3.5) were consistently higher than during extinction components (*M* = 0.7). Responding was similarly low across both reinforcement (*M* = 1.8) and extinction (*M* = 1.4) components of the mixed arrangement. When given a choice among the three arrangements, Chuck did not meet either restriction criteria within 30 sessions. Nevertheless, Chuck selected the S+ on 14 opportunities and the mixed arrangement on 11 opportunities. The S+/S− was selected the least often (five opportunities).

Carl engaged in elevated rates of responding during reinforcement components (*M* = 10) and in low rates during extinction components (*M* = 1.8) of the S+/S− arrangement. He engaged in similar patterns when the S+ was arranged (*M*s = 9.5 during reinforcement and 1.6 during extinction components). His re-

Table 1
Effectiveness of the S+/S−, S+, and Mixed Arrangements

	Reinforcement responses per minute			Extinction responses per minute			Discrimination index		
Child	S+/S−	S+	Mixed	S+/S−	S+	Mixed	S+/S−	S+	Mixed
Josh	8.4	9.1	2.4	0.7	0.7	1.1	.93	.93	.69
Ana	9.7	6.6	5.3	1.3	0.8	2.8	.88	.89	.65
John	2.3	3.8	1.0	0.4	0.5	0.3	.86	.88	.77
Carl	10.3	9.7	4.0	1.8	1.9	2.4	.85	.84	.62
Emma	6.4	3.6	4.1	1.7	0.8	2.0	.79	.82	.67
Joe	10.4	10.1	5.4	3.8	3.4	3.2	.73	.75	.63
Chuck	4.4	6.3	3.0	1.7	1.4	2.1	.72	.82	.59

sponding was variable and indiscriminate under the mixed arrangement (*M*s = 1.8 during reinforcement and 1.4 during extinction components). When given a choice among the three arrangements, Carl did not meet the restriction criteria within 30 sessions. He selected the S+ arrangement most often (13 times); similar numbers of mixed (nine) and S+/S− (eight) selections were observed.

To permit comparisons of the relative effectiveness of the three arrangements for all 7 children, a data summary is provided in Table 1. The data are summarized across the forced-choice phase of the experiment only (i.e., the portion conducted within the multielement experimental design). One measure of the effectiveness of these arrangements is the extent to which each maintained responding during reinforcement periods. Therefore, individuals' reinforcement-component response rates are listed in the first set of columns. Overall reinforcement response rates were higher during S+/S− ($M = 7.4$ responses per minute) and S+ ($M = 7$) than during the mixed arrangement ($M = 3.6$) for 6 of 7 participants (Emma's responding during the mixed arrangement was higher than during the S+ arrangement). Reinforcement response rates were elevated during the S+/S− condition relative to the S+ for 4 of 7 participants. These differences ranged from 0.3 to 3.1 responses per minute.

A second measure of effectiveness is the extent to which each arrangement reduced responding during extinction periods. Therefore, extinction-component response rates are listed in the second set of columns in Table 1. The mixed arrangement resulted in the highest levels of extinction responding for 6 of 7 participants. For 3 of the 7 participants, the S+ arrangement resulted in the lowest rates of extinction responding, and for 3 participants, the S+/S− resulted in the lowest rates (Josh's extinction response rates were lower during S+/S− when carried out to the third decimal place). The differences between extinction responding during the S+/S− and S+ arrangement were small (0 to 0.9 responses per minute across participants).

A third measure of effectiveness of multiple schedules is the extent to which each arrangement promoted discriminated responding. That is, to what extent did participants respond during reinforcement periods relative to extinction periods? Discrimination indexes were calculated by summing the total number of responses emitted during reinforcement components and dividing the sum by the total number of responses emitted (i.e., responding during both reinforcement and extinction components). The closer the number was to 1, the stronger the discrimination; the closer the number was to .5 (i.e., chance-level responding), the weaker the discrimination. These discrimination indexes are presented in the third set of columns in Table 1. For all participants, both the S+/S− and S+ arrangements resulted in higher discrimination indexes than the mixed arrangement. For 5 of the 7 participants, the S+ arrangement resulted in the highest discrimination indexes. However, these differences were quite small (0 to .1). Taken as a whole, these results show that the presentation of an explicit extinction-correlated stimulus was not necessary in the development of discriminated responding. That is, the S+ arrangement was found to result in response patterns similar to those of the S+/S− arrangement for the 7 participants.

Although response rates were similar for the S+/S− and S+ arrangements, distinct preferences were observed between the two arrangements. Three participants preferred the S+/S− condition (i.e., Ana, Josh, and John), and 4 participants preferred the S+ condition (i.e., Chuck, Carl, Emma, and Joe). We conducted several correlational analyses involving performance data (from the forced-choice phase; Table 1) and preference data (from the free-choice phase) to begin to understand why some children preferred the S+/S− arrangement and others preferred the S+ arrangement. The results of these analyses, using Spearman rank correlations, are shown in Table 2.

Higher levels of obtained reinforcement may be responsible for a preference for one of the multiple-schedule arrangements; therefore, the association between reinforcement-component response rates and S+/S− and S+ selections was determined. Reinforcement-component response rates during both the S+/S− and S+ conditions were uncorrelated with selections of both arrangements (i.e., different rates of reinforcement were not associated with children's preferences for either the S+/S− or the S+ arrangements).

Terrace (1971) suggested that a history of responding in the presence of extinction-correlated stimuli could create an aversion to S−. Therefore, we calculated the correlation between responding in the presence of the S− (i.e., S+/S− extinction responding) and selections of the S+/S− and S+ arrangements. A moderate negative correlation between S+/S− responding and S+/S− selections existed ($r = -0.74$), suggesting that the preference for the S+/S− condition was less likely given high levels of errors in the presence of the S− stimulus. However, this correlation was not statistically significant ($p = .058$).

Table 2

Correlations Between Performance Measures and S+/S− and S+ Selections

Independent variable	*r* value S+/S− selections	*r* value S+ selections
S+/S− reinforcement	−0.18	0.46
S+ reinforcement	−0.07	0.14
S+/S− extinction responding	−0.74	0.58
S+ extinction responding	−0.63	0.52
S+/S− discrimination index	.86*	.43
S+ discrimination index	.96*	.58

* $p < .05$.

A stronger positive correlation existed between the discrimination index obtained in the S+/S− condition and selections of this condition ($r = 0.86$; $p = .014$). That is, children who responded most effectively (relatively higher rates during reinforcement and relatively lower rates during extinction) were the most likely to prefer the S+/S− condition. By contrast, children who responded less effectively (evident by lower discrimination indexes) were more likely to prefer the S+ arrangement. However, it is also interesting to note that discrimination indexes during the S+ condition were positively correlated with S+/S− selections ($r = 0.96$; $p = .001$). In other words, children who engaged in higher levels of discriminated responding in both the S+/S− and the S+ conditions tended to prefer the S+/S− condition.

DISCUSSION

The present experiment evaluated both the effectiveness of and children's preferences for two variations of a multiple-schedule arrangement used to generate discriminated social behavior during teaching situations common to preschool classrooms. There were two primary findings. First, explicit extinction-correlated stimuli were not necessary to produce discriminated requesting in young children (i.e., the S+/S− and the S+ arrangements were equally effective). Second, and consistent with Terrace's (1971) results, children's preferences for multiple-schedule arrangements were affected by the presentation of an explicit stimulus during extinction periods. Conditions in which the S− was absent were preferred by 4 children who had a history of responding in the presence of the extinction-correlated stimulus. However, conditions in which the S− was present were preferred by 3 children who rarely responded in the presence of the extinction-correlated stimulus.

Case, Fantino, and Wixted (1985) described conditions in which extinction-correlated stimuli would function as reinforcers. In this study with college students, pulling a plunger intermittently earned points and pressing an observing button intermittently signaled extinction periods (e.g., a blue light turned on if an extinction period was programmed) but not reinforcement periods (i.e., no light turned on if a reinforcement period was programmed). These students' button presses were elevated compared to conditions in which points were delivered on fixed-time schedules (i.e., response independently; Fantino & Case, 1983). In other words, presentation of the S− reinforced button pressing only when the presentation of the S− allowed the participants to respond more efficiently (i.e., reduced the number of nonreinforced plunger pulls). This relation was present in the current study as well, as evidenced by the strong positive correlations between discrimination indexes and S+/S− selections. Participants who responded most efficiently (i.e., with the highest discrimination indexes) were likely to prefer the S+/S− condition, whereas participants who responded inefficiently (i.e., with the lowest discrimination indexes) were likely not to prefer the S+/S− condition.

Using children's discrimination indexes (a measure of efficiency) during the forced-choice phase of the S+/S− condition as an independent variable, we calculated a regression equation that should allow predictions of children's preferences for S+/S− conditions during the preference assessment. This line is best represented by the equation $Y' = 405.6x - 292.5$, where x is the observed discrimination index, 405.6 is the slope of the line, -292.5 is the point at which the line intercepts the y axis, and Y' is the expected value of S+/S− selections. Using this equation, if we set the value of Y' to 33% (the point at which selections are indifferent between terminal links), we solve for the value of x to be .8. In other words, if children experienced the identical conditions present during the forced-choice phase of this experiment, we would predict that the S+/S− condition would be preferred by those whose discrimination indexes were higher than .8, and the S+/S− condition would be nonpreferred by those whose discrimination indexes were .8 or lower. Although the predictive validity of this equation will need to be determined through replication in future research, the data generated by this equation provide tentative guidance for determining whether S+/S− or S+ arrangements should be used during instructional situations. In other words, selection of the multiple-schedule arrangement should be determined by the extent to which discrimination training resulted in errorless or error-prone acquisition.

Errorless training can be conducted by arranging initially brief extinction periods and then gradually extending their duration. For instance, in the treatment of severe problem behavior, Hanley et al. (2001) arranged a multiple schedule in which extinction periods were initially 15 s (relative to 45-s reinforcement periods); extinction periods were then gradually increased to 4 min. In this manner, responses were unlikely to be emitted in the presence of the S−, resulting in relative high discrimination indexes. S+/S− multiple schedules should be preferred following this training procedure.

Error-prone teaching can be conducted by arranging extended periods of extinction from the onset of training and allowing the process of extinction to reduce responding during these periods. For instance, following functional communication training, Hagopian et al. (2004) arranged a multiple schedule in which extinction periods were 9 min in duration and reinforcement periods were 1 min in duration. Following exposure to these conditions, extinction responding was reduced to low levels. Using this technique, responses were likely to be emitted in the presence of the S−, resulting in relatively low discrimination indexes. S+/S− multiple schedules should be nonpreferred following this training procedure (i.e., the S+ arrangement would likely be preferred).

Although the predictions made by the regression equation were based on S+/S− discrimination indexes, it is important to note that there were other potential predictor variables (i.e., discrimination index during the S+ or combining the discrimination indexes between the S+/S− and S+ conditions). Predictions were based on the response patterns in the S+/S− condition because previous research (Case et al., 1985; Terrace, 1971) has suggested that individuals' histories of responding in relation to the S− are likely to affect the value of this particular stimulus. Future research may better determine which of these historical variables most directly affects individuals' preferences for or against S− stimuli.

Future research may also identify particular behavioral characteristics that may predict children's performances in multiple-schedule arrangements (i.e., what personal histories lead some children to engage in highly discriminated responding while others persist with extinction responding). These differences may include the strength of children's verbal repertoires, their sensitivity to presession instructions, and the value of attention as a reinforcer. For instance, in a study with pigeons responding in a multiple-schedule arrangement, Powell (1973) found that increased food deprivation resulted in subsequently decreased discrimination indexes via the persistence of responding during extinction. In other words, following deprivation of the reinforcer, responding was more likely to be evoked under extinction conditions. Thus, children who are highly motivated to gain attention may be more likely to recruit attention under extinction conditions, thus lowering their discrimination indexes and increasing their likelihood of preferring the S+ condition.

Assessing children's preferences for behavioral interventions and refining them accordingly can be considered an application of Wolf's (1978) concept of social validity. That is, if behavioral interventions are to be adopted, they must not only treat the target behavior of interest but also be acceptable to the parents or teachers who implement them and to the consumers who receive them. It is the last category in which the present study falls. Preschoolers' preferences for multiple-schedule arrangements can be viewed as a direct measure of social validity from the consumers of the intervention, the children themselves. Although these measures may aid in the adoption of multiple-schedule procedures in general, or specific variations of multiple-schedule procedures under different training conditions, it will also be important to assess the acceptability of these interventions with teachers. It is possible that teachers will find the use of leis too artificial for classroom use. Future research should examine the use of a more natural signal, such as brief vocalizations, as discriminative stimuli for reinforcement and extinction periods. If effective, this variation would likely be more appealing and less effortful to maintain.

REFERENCES

Case, D. A., Fantino, E., & Wixted, J. (1985). Human observing: Maintained by negative informative stimuli only if correlated with improvement in response efficiency. *Journal of the Experimental Analysis of Behavior, 43,* 289–300.

Fantino, E., & Case, D. A. (1983). Human observing: Maintained by stimuli correlated with reinforcement but not extinction. *Journal of the Experimental Analysis of Behavior*, *40*, 193–210.

Fisher, W. W., Kuhn, D. E., & Thompson, R. H. (1998). Establishing discriminative control of responding using functional and alternative reinforcers during functional communication training. *Journal of Applied Behavior Analysis*, *31*, 543–560.

Hagopian, L. P., Toole, L. M., Long, E. S., Bowman, L. G., & Lieving, G. A. (2004). A comparison of dense-to-lean and fixed lean schedules of alternative reinforcement and extinction. *Journal of Applied Behavior Analysis*, *37*, 323–337.

Hanley, G. P., Iwata, B. A., & Thompson, R. H. (2001). Reinforcement schedule thinning following treatment with functional communication training. *Journal of Applied Behavior Analysis*, *34*, 17–38.

Hanley, G. P., Piazza, C. C., Fisher, W. W., Contrucci, S. A., & Maglieri, K. (1997). Evaluation of client preference for function-based treatment packages. *Journal of Applied Behavior Analysis*, *30*, 459–473.

Hanley, G. P., Tiger, J. H., Ingvarsson, E. T., & Cammilleri, A. C. (in press). Influencing preschoolers' activity preferences: An evaluation of satiation and embedded reinforcement. *Journal of Applied Behavior Analysis*.

Heal, N. A., & Hanley, G. P. (in press). Evaluating preschool children's preferences for motivational strategies during instruction. *Journal of Applied Behavior Analysis*.

Mulvaney, D. E., Dinsmoor, J. A., Jwaideh, A. R., & Hughes, L. H. (1974). Punishment of observing by the negative discriminative stimulus. *Journal of the Experimental Analysis of Behavior*, *21*, 37–44.

Neidert, P. L., Iwata, B. A., & Dozier, C. L. (2005). Treatment of multiply controlled problem behavior with procedural variations of differential reinforcement. *Exceptionality*, *13*, 45–53.

Powell, R. W. (1973). Effects of stimulus control and deprivation upon discriminative responding. *Journal of the Experimental Analysis of Behavior*, *19*, 351–360.

Sidener, T. M., Shabani, D. B., Carr, J. E., & Roland, J. P. (in press). An evaluation of strategies to maintain mands at practical levels. *Research in Developmental Disabilities*.

Terrace, H. S. (1971). Escape from S−. *Learning and Motivation*, *2*, 148–163.

Tiger, J. H., & Hanley, G. P. (2004). Developing stimulus control of preschooler mands: An analysis of schedule-correlated and contingency-specifying stimuli. *Journal of Applied Behavior Analysis*, *37*, 517–521.

Tiger, J. H., & Hanley, G. P. (2005). An example of discovery research involving the transfer of stimulus control. *Journal of Applied Behavior Analysis*, *38*, 499–509.

Wolf, M. M. (1978). Social validity: The case for subjective measurement or how applied behavior analysis is finding its heart. *Journal of Applied Behavior Analysis*, *11*, 203–214.

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