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Comparison of synchronous reinforcement and accumulated reinforcement for increasing on-task behavior in preschoolers

Sara C. Diaz de Villegas | Claudia L. Dozier | Ky C. Kanaman | Stacha C. Leslie | Marissa E. Kamlowsky

Department of Applied Behavioral Science, University of Kansas, Lawrence, Kansas, USA

Correspondence
Sara C. Diaz de Villegas, Department of Applied Behavioral Science, University of Kansas, Lawrence, KS 66045, USA.
Email: saraddv@ku.edu

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Abstract

In synchronous-reinforcement schedules, the duration of behavior directly controls the duration of reinforcement on a moment-to-moment basis. We replicated and extended Diaz de Villegas et al. (2020) by comparing the effects of synchronous reinforcement with two accumulated-reinforcement schedules for increasing on-task behavior for seven preschoolers. One accumulated schedule was the same as the one used in Diaz de Villegas et al. and did not include tokens, whereas the other accumulated schedule included the delivery of tokens within session. Furthermore, we assessed preference for the three reinforcement schedules. The results showed that synchronous reinforcement was effective for increasing on-task behavior for all seven participants. Furthermore, it was most effective for increasing on-task behavior for three out of seven participants and preferred by all participants. For some participants, other schedules were also similarly effective. The results are discussed with respect to implications for application.

KEYWORDS
accumulated reinforcement, on-task behavior, preschoolers, schedules of reinforcement, synchronous reinforcement

Early research by Ferster and Skinner (1957) sparked numerous studies to determine patterns of responding produced by various reinforcement schedules for both humans and nonhuman species (e.g., Lattal & Neef, 1996; Lerman et al., 1996; Mace et al., 2021). However, most research on schedules of reinforcement has been conducted using discrete (discontinuous) operant responses and discrete (discontinuous) reinforcing events (Lattal & Neef, 1996), which has been referred to as an episodic or discontinuous relation (Williams & Johnston, 1992). Furthermore, most applications of reinforcement schedules have involved schedules that include an episodic relation using common schedules of reinforcement (see Mace et al., 2021, for an overview). For example, under a fixed-ratio schedule for maintenance of correct responding in an early intervention program, a child may be provided a small quantity of a reinforcing stimulus to consume (e.g., bite-sized edible) each time they complete a specified number of responses.

Most research has focused on the count and time dimensions (rate and interval schedules) that were initially proposed by Ferster and Skinner as opposed to the multitude of ways that behavior–environment relations may, and likely do, occur (Morgan, 2010). Various researchers have called for the study of more dynamic (nonepisodic) schedules that are likely working in the natural environment, which are quite different from commonly studied schedules (Morgan, 2010; Williams & Johnston, 1992). Schedules in the natural environment likely involve a reciprocal relation, with multiple individuals' behavior functioning as antecedent and consequent stimuli in a more dynamic process. For example, a child may engage in tantrums that are reinforced by access to caregiver attention and variations in attention delivery (e.g., duration, topography) may covary with the duration or intensity of the tantrum. Similarly, variations in an infant's crying (e.g., intensity, pitch, duration) may covary with the latency, topography, and frequency of parent interaction. Finally, the moment-to-moment changes in responding when engaging in complex repertoires, such as playing the piano, covary with moment-to-moment changes in sound from the instrument. Thus, Williams and Johnston (1992) proposed studying schedules of reinforcement in which responses and reinforcers

covary such that variation in some dimension of the response produces variation in some dimension of the consequence. These schedules have been termed *schedules of covariation*, which are continuous reinforcement schedules in which variations in some parameter of the response (e.g., intensity, duration, speed) covary with some dimension of the reinforcer (e.g., intensity, duration; Biddiss & Irwin, 2010; Faith et al., 2001; Williams & Johnston, 1992).

One type of schedule of covariation is the synchronous-reinforcement schedule, where the onset and offset of the response (i.e., response duration) is perfectly synchronized with the onset and offset of the reinforcer (Ramey et al., 1972; Rovee-Collier & Gekoski, 1979; Weisberg & Rovee-Collier, 1998; Williams & Johnston, 1992). For example, when a child holds down or continuously presses a button on a toy light saber (response onset), the toy continuously makes sounds and lights up; however, when the child stops pressing the button (response offset), the sound and light turn off. Synchronous schedules may be beneficial for influencing behavior change, particularly for duration-based behaviors (e.g., cleaning up toys, playing interactively with peers, engaging in social interactions, exercising) because the response dimension is aligned with the programmed reinforcer dimension.

Research on synchronous-reinforcement schedules has been limited. Earlier research on synchronous schedules has focused on using a synchronous reinforcement preparation to study other phenomena such as infant cognition and discrimination of auditory and visual stimuli (e.g., Friedlander, 1966; Horowitz, 1974a, 1974b; Leuba & Friedlander, 1968; Pelaez-Nogueras et al., 1996, 1997; Siqueland, 1968; Siqueland & Lipsitt, 1966; Smith et al., 1963) and for determining preference and reinforcer efficacy of stimuli for infants and individuals with intellectual and development disabilities (e.g., Saunders et al., 2001, 2003; Saunders & Saunders, 2011; Striefel & Smeets, 1974). However, only a few studies have evaluated the efficacy of synchronous schedules for producing important behavior change (e.g., Biddiss & Irwin, 2010; Diaz de Villegas et al., 2020; Faith et al., 2001; Hardesty et al., 2023; McHugh et al., 2022; Ramey et al., 1972). For example, Faith et al. (2001) showed that synchronous delivery of TV access was more effective than noncontingent TV access for increasing physical activity of 10 obese children. Furthermore, McHugh et al. (2022) recently showed the efficacy of a synchronous schedule of preferred media access (TV shows, music, movies) for increasing mask wearing with adults with intellectual and developmental disabilities during the COVID-19 pandemic.

Although several studies have shown the efficacy of synchronous reinforcement for changing socially important behavior, few studies have compared the effects of synchronous schedules with those of other schedules of reinforcement, particularly episodic schedules typically found in applied contexts (Lattal & Neef, 1996; Mace et al., 2021). Furthermore, schedules of covariation such as synchronous schedules are likely ubiquitous in our everyday lives and are more in line with complex and dynamic relations between responses and reinforcers; thus, continued research on these schedules and comparisons with episodic schedules is needed. Research comparing synchronous reinforcement with more common episodic schedules of reinforcement would allow researchers to determine the conditions under which they are most likely to be effective. To address these limitations in the literature and add to a small body of research on synchronous reinforcement, Diaz de Villegas et al. (2020) compared the efficacy of a synchronous schedule of reinforcement (nonepisodic schedule) with that of an accumulated schedule of reinforcement (episodic schedule) for increasing on-task behavior for preschoolers. During baseline sessions, engaging in on-task behavior (i.e., tracing) resulted in no programmed consequences. During synchronous sessions, reinforcers (i.e., music and conversation) were delivered when the participant was engaged in on-task behavior (i.e., tracing). That is, the onset of on-task behavior was perfectly synchronized with the onset of reinforcer delivery and the offset of the behavior resulted in the discontinuation of the reinforcer. During accumulated sessions, the duration of on-task behavior during the session was yoked to, or matched, the duration of continuous access to the reinforcer, which was delivered at the end of the session. After the comparison of the two reinforcement schedules, the experimenters also assessed preference for the schedules using a concurrent-chains procedure (Hanley et al., 2005). The results showed that both synchronous and accumulated schedules were effective for increasing on-task behavior relative to baseline levels for three out of eight preschoolers; moreover, synchronous reinforcement resulted in higher levels of on-task behavior for seven out of eight preschoolers. Additionally, those seven preschoolers preferred the synchronous schedule relative to the accumulated schedule; the eighth participant did not show a clear preference.

However, one limitation of the study by Diaz de Villegas (2020) was that the accumulated condition that was used as the control (or comparison) condition differed from how accumulated schedules are typically programmed in the literature. Accumulated schedules typically involve the delivery of conditioned reinforcers such as tokens throughout the session to signal the accumulation of reinforcement and provide feedback regarding performance within session (e.g., DeLeon et al., 2014; Frank-Crawford et al., 2019). A logical avenue for future research is to compare synchronous reinforcement with an accumulated schedule where tokens are delivered to signal the accumulation of reinforcement. Therefore, the purpose of the current study was to replicate and extend Diaz de Villegas et al. by addressing the limitation associated with the accumulated condition. Specifically, in the current study we compared the effects of synchronous reinforcement with those of two accumulated schedules. One accumulated schedule was the same as the one used

in Diaz de Villegas et al. in which tokens were not arranged for on-task behavior; the other accumulated schedule was similar but involved the delivery of tokens within the session. We also determined participant preference for the three schedules of reinforcement.

METHOD

Participants

Participants were seven children who attended a university-based preschool and whose parents reported no known diagnoses. Table 1 provides participant demographic information as reported by parents in their preschool intake and enrollment paperwork. Inclusion in the current study was based on teacher report and informal observations conducted by the experimenters that participants met the following criteria: participants could (a) follow multistep instructions (e.g., walk to your cubby, put your backpack away, and sit down), (b) remain seated for more than 5 min, and (c) hold a writing utensil to trace letters. This study received approval by the Institutional Review Board and was conducted in accordance with established ethical guidelines for the treatment of human participants. Parents provided written consent permitting their child to participate in the study. Assent was provided by the participants prior to each session by asking them if they wanted to attend research; participants could withdraw their assent at any point such that they could quit, leave, or refuse any part of the research study at any time.

Setting and materials

Trained graduate students conducted sessions in rooms (approximately 3 × 2.7 m) that contained a table, chairs, and relevant session materials. All sessions were 5 min and were conducted in a session block, with each session block consisting of three sessions conducted consecutively. However, for accumulated and accumulated-token sessions, total time in the session room could be up to 10 min. Specifically, the session duration was 5 min in all sessions; however, participants could earn up to 5 min of reinforcer access following the session, resulting in a maximum of 10 min in the session room for those two conditions.

During all sessions, target task materials, an alternative task, and a dry-erase marker were present. Target task materials included a stack of laminated letter-tracing worksheets that were three-hole punched and presented in a binder. The letter-tracing worksheets included three rows of letters by three columns of letters for a total of nine consecutive letters on each worksheet, presented in alphabetical order; the letters were in alphabetical order until all 26 letters had been presented. Alternative task materials included a stack of blank laminated sheets that were three-hole punched and presented in a binder; the participants could draw or write on these sheets. An alternative task was available in all sessions to decrease the likelihood that participants engaged in the target task because there was nothing else to do during the session. To aid in discrimination across conditions, each condition was associated with a unique color. Within a given condition, we arranged worksheets, blank laminated sheets, binders, and tablecloths using the respective color.

During reinforcement sessions, the experimenter presented the participant with an individualized song board. The song board was a white laminated poster board (measuring 55.8 × 71.1 cm) with 10–15 laminated picture icons (measuring 4.5 × 3 cm) that corresponded with 10–15 songs, with Velcro strips affixed to the back such that they could be attached to the poster board. During reinforcement sessions, the experimenter also had an iPod touch with a playlist containing the songs depicted on the song board. During accumulated-reinforcement sessions, the experimenter presented a token board with 10 spots for tokens. The token board was a yellow laminated sheet with 10 Velcro strips affixed to the front (five strips across the top of the sheet and five on the bottom) such that laminated square-shaped yellow tokens with a thick black border (measuring 4.5 × 3 cm) could be attached to the token board. The experimenter used a silent timer during accumulated-reinforcement conditions to measure the duration of on-task behavior to determine reinforcer delivery in accumulated-reinforcement conditions (see below).

TABLE 1 Participant demographic information.

Participant	Age	Gender	Race/Ethnicity
Willie	5	Male	White
Remy	5	Male	Hispanic/Latino
Angie	4	Female	White
Eleanor	4	Female	White
David	4	Male	White/Hispanic
Garrett	5	Male	White
Louise	4	Female	White

Note: The category label "Gender" and "Male" and "Female" options is used to denote correspondence with child-intake forms completed by parents for enrollment.

Response measurement, interobserver agreement, and procedural fidelity

Graduate students and undergraduate research assistants were trained observers who collected data using handheld data-collection devices. The dependent variable was the duration of on-task behavior (letter tracing), which was scored if the participant was moving the marker steadily and approximately within the boundaries of the thick preprinted lines on the letter-tracing worksheet or turning over the worksheet page to access a new worksheet

without pausing for more than 2 s. On-task behavior was not scored if more than 2 s passed with the participant lifting the marker away from the tracing worksheet, coloring anywhere outside or inside of the thick preprinted lines on the worksheet (e.g., shading the area between the lines with the marker, outlining the area around the thick lines, coloring the entire letter), or physically manipulating the marker in a manner that prevented tracing (e.g., rolling, tapping, or throwing marker). During the preference assessment, trained observers collected data on the condition selected by the participants and the duration of on-task behavior.

A second independent observer collected data for at least 30% of all sessions for each participant across all conditions. Interobserver agreement was determined by using an exact agreement method to analyze second-by-second, within-session responding. An agreement on a particular second was defined as both data collectors scoring the occurrence or nonoccurrence of the behavior on a given second. Interobserver agreement was calculated as described by Diaz de Villegas et al. (2020) by dividing the number of seconds in the session with an agreement by the total number of seconds and multiplying by 100. Interobserver agreement was calculated for 60% of sessions for Angie, and mean agreement for on-task behavior was 94% (range: 83%–100%). Interobserver agreement was calculated for 43% of sessions for David, and mean agreement for on-task behavior was 97% (range: 92%–100%). Interobserver agreement was calculated for 34% of sessions for Eleanor, and mean agreement for on-task behavior was 95% (range: 84%–100%). Interobserver agreement was calculated for 54% of sessions for Garrett, and mean agreement for on-task behavior was 95% (range: 86%–100%). Interobserver agreement was calculated for 35% of sessions for Louise, and mean agreement for on-task behavior was 97% (range: 93%–100%). Interobserver agreement was calculated for 47% of sessions for Remy, and mean agreement for on-task behavior was 94% (range: 85%–99.6%). Interobserver agreement was calculated for 58% of sessions for Willie, and mean agreement for on-task behavior was 98% (range: 88%–100%).

During the preference assessment, interobserver agreement was calculated for selection of a procedure using the total agreement method. An agreement was scored if both observers agreed on the procedure selected, and a disagreement was scored if there was a discrepancy between the two observers. Thus, interobserver agreement for selection for a particular session was either 100% (the two observers agreed) or 0% (the two observers disagreed). Interobserver agreement was calculated for at least 30% of sessions for all participants, and mean agreement was 100% for all participants.

We calculated procedural fidelity for approximately 90% of all reinforcement sessions (i.e., synchronous, accumulated, and accumulated-token reinforcement) for each participant across reinforcer conditions to determine whether the experimenter correctly implemented the programmed contingencies. For synchronous- and accumulated-reinforcement sessions, observers collected data on the duration of reinforcer delivery, which was defined as the period of onset and removal of the reinforcer. For synchronous- and accumulated-reinforcement sessions, we calculated procedural fidelity by comparing the outcomes of two measures (i.e., on-task duration and reinforcer delivery duration) by dividing the smaller duration by the larger duration and multiplying by 100. For accumulated-token-reinforcement sessions, observers collected data on experimenter delivery of tokens. We defined token delivery as the experimenter placing a token on the token board within 3 s of the participant engaging in 30 s of cumulative on-task behavior. For accumulated-token-reinforcement sessions, we calculated procedural fidelity by dividing the duration of on-task behavior by 30 s (i.e., the criterion duration for token delivery) to get the total number of tokens that should have been delivered. The outcome of this calculation was then compared with the total amount of tokens delivered during the session. To do so, we divided the smaller number of tokens delivered by the larger number of tokens delivered and multiplied by 100. Procedural fidelity was calculated for at least 92% of reinforcement conditions and 89% of all accumulated-token-reinforcement sessions across all participants. Mean procedural fidelity for reinforcer delivery across participants was 95% (range: 93%–98%). Mean procedural fidelity for token delivery across participants was 95% (range: 91%–100%). Additionally, the lead experimenter retrained experimenters on the operational definition of reinforcer delivery and token delivery across conditions to ensure understanding of when the reinforcer and tokens should and should not be delivered.

Determining preferred songs

Prior to the study, the experimenter asked (a) parents or caregivers of the children who were recruited for our study to list 10 songs that their children prefer and (b) children to list five songs they prefer; the experimenters also played songs that were commonly played in the classroom and asked the children whether they liked those songs and wanted them included for research sessions. Furthermore, participants could request additional songs not shown on their individualized song board to be used during reinforcement phases.

Song-board training

Prior to the study, the experimenter familiarized participants with the songs associated with the different pictures on the individualized song board by conducting three

song-board exposure sessions. During these sessions, the experimenter pointed to each picture on the song board, told the participant the name of the song, and played a brief clip (10 s) of the song.

General procedures

During all sessions, the experimenter was seated across the table from the participant and presented them with two binders; one contained a large stack of three-hole-punched laminated tracing sheets (target task), and the other contained a large stack of three-hole-punched laminated blank drawing sheets (alternative task). The binders were placed on the table in front of the participant (approximately 27 cm apart) with a dry-erase marker placed between them. The binders contained a large stack of sheets such that the participant would not run out of materials for either task. Prior to all sessions, the experimenter conducted two consecutive brief exposure trials, 10 s in duration across all conditions. That is, the experimenter presented a large stack of both sheets in their respective binders, provided a brief rule (see Appendix A for all condition-specific instructions) stating the contingencies associated with the condition, and provided brief exposure to the session contingencies programmed for on-task behavior. Specifically, the experimenter told the participant that they were going to practice what happened in the condition and provided exposure to the session contingencies programmed for on-task behavior. For preexposure to all reinforcement conditions (i.e., synchronous, accumulated, accumulated tokens), the experimenter presented the song board to the participant and asked them to pick the songs (by touching the picture, pointing to the picture, or saying the name of the song) they wanted to hear the most (typically three songs).

During all reinforcement sessions in the reinforcer evaluation, the experimenter provided access to the requested songs in the order in which they were selected and attention in the form of conversation while the songs were playing. The type of attention delivered by the experimenter consisted of making statements about the song (e.g., "This song is so much fun!"), discussing preferred shows, and talking about classmates and activities (e.g., playing outside with friends on the playground). We chose to include attention delivery because when the lead experimenter conducted pilot sessions with other children who were not included in the study, they would attempt to speak with the experimenter while the songs were playing. Additionally, music is typically played in the classrooms and teachers in the preschool classrooms are trained to interact with the children; therefore, combining the delivery of attention and access to songs more closely resembled how these reinforcers are typically delivered in the everyday environment.

Baseline

During baseline sessions, the task materials and tablecloth were white. The experimenter conducted two brief presession exposure trials and told the participant the condition-specific rules (see Appendix A). During exposure trials, the experimenter told the participant, "Let me show you what will happen when you trace the [letters]," prompted the participant to trace for approximately 10 s, and provided no programmed consequences. Following presession exposure, the session began. During the session, the experimenter did not deliver any programmed consequences for engaging in the target task or any other behavior.

Synchronous reinforcement

During synchronous-reinforcement sessions, the task materials and tablecloth were blue. The experimenter conducted two brief presession exposure trials and told the participant the condition-specific rules (see Appendix A). During exposure trials, the experimenter told the participant, "Let me show you what will happen when you trace the [letters]," prompted the participant to trace for approximately 10 s, and provided access to a preferred song and attention throughout that 10 s; the experimenter also had the participant stop tracing such that the music was paused and they stopped talking. Following presession exposure, the session began. During the session, the experimenter provided access to preferred songs and attention in the form of conversation while the participant was engaging in the task (based on the operational definition of on-task behavior); however, if the participant stopped engaging in the task for more than 2 s (based on the operational definition of on-task behavior), the experimenter paused the song and stopped providing attention until the participant resumed engaging in the task.

Accumulated reinforcement

During accumulated-reinforcement sessions, the task materials and tablecloth were red. The experimenter conducted two brief presession exposure trials and told the participant the condition-specific rules (see Appendix A). During exposure trials, the experimenter told the participant, "Let me show you what will happen when you trace the [letters]," prompted the participant to trace for approximately 10 s, and provided access to preferred songs and attention in the form of conversation at the end of the presession exposure for the duration of time spent engaging in the task (i.e., 10 s); the experimenter also had the participant stop tracing such that they did not earn access to songs and attention for the full 10 s (i.e., they traced for approximately 5 s and earned approximately 5 s of access to songs and attention).

Following presession exposure, the session began. During the session, the experimenter did not deliver any programmed consequences; however, at the end of the session they yoked the duration of access to the preferred songs and attention to the duration of task engagement (based on the operational definition of on-task behavior) during the session. To determine this duration, the experimenter used a silent timer (e.g., iPod touch timer), which was hidden from the view of the participant, to measure on-task behavior during the session.

Accumulated reinforcement tokens

During accumulated-reinforcement-with-token sessions, the task materials and tablecloth were yellow. The experimenter conducted two brief presession exposure trials and told the participant the condition-specific rules (see Appendix A). During exposure trials, the experimenter told the participant, "Let me show you what will happen when you trace the [letters]," prompted the participant to trace for approximately 10 s, and delivered a token on the token board. Then, the experimenter prompted the participant to trace for approximately another 10 s, delivered another token on the token board, and provided access to a preferred song and attention in the form of conversation at the end of the presession exposure for the duration of time spent engaging in the task (i.e., 20 s). Following presession exposure, the session began. During the session, the experimenter delivered a token contingent on the participant engaging in 30 s of cumulative on-task behavior. Therefore, the participant did not need to engage in 30 s of on-task behavior consecutively. For example, the participant could engage in on-task behavior for 10 s, pause for 12 s, and then engage in on-task behavior for 20 s, for a total of 30 s, which resulted in the delivery of a token. Furthermore, although the tokens were delivered for engaging in 30 s of cumulative on-task behavior, if the participant engaged in on-task behavior for less than 30 s and therefore did not produce a token, they still earned that duration of reinforcer access following the 5-min session. Participants had the opportunity to earn 10 tokens during the session. No other consequences were programmed during the session; at the end of the session, the experimenter yoked the duration of access to the preferred songs and attention to the duration of task engagement (based on the operational definition of on-task behavior) during the session. To determine this duration, experimenters used the same method of yoking as previously described in the accumulated condition.

Experimental design and secondary data analysis

For all participants, we used a multielement design to compare the effects of the three reinforcement schedule conditions in the reinforcer evaluation. After we determined baseline levels of on-task behavior for each participant, we alternated synchronous-reinforcement sessions, accumulated-reinforcement sessions, and accumulated-reinforcement-with-tokens sessions during each session block. The order of these different sessions for each session block was determined by pulling the condition name out of a cup. Thus, each three-session block included one session of each condition. However, for two of the initial participants (i.e., Remy and Garrett) during their initial sessions, this session-block order was not followed. That is, their session order in a session block was quasirandom in that session order was determined by pulling the condition name out of a cup from the pool of all three conditions but with the stipulation that no more than two sessions of the same condition were conducted consecutively. For example, a three-session block for Remy and Garrett may have consisted of two sessions of accumulated and one session of synchronous reinforcement and no accumulated-token condition in that block. This was remedied so that subsequent three-session blocks included one session of each condition. For participants who engaged in similar levels of on-task behavior across conditions (i.e., little or no differentiation across conditions) in the multielement phase of the study, we used a nonconcurrent multiple-baseline-across-participants design to show experimental control (David, Garrett, and Louise).

To clarify the patterns of responding that were obtained in the current study, we conducted additional within-session, second-by-second analyses for all conditions (i.e., baseline, synchronous, accumulated, accumulated token). That is, in addition to graphing and analyzing our primary dependent variable, duration of on-task behavior, we calculated bouts of on-task behavior, within-session pausing, and within-session pausing following token delivery for all participants to examine whether different experimental conditions produced different patterns of responding and assess the potential disrupting effect of token delivery on responding (see graphs for individual participants in Results; also see Supporting Information A, B, C, and D). To calculate bouts of within-session responding, the experimenters summed continuous instances of on-task behavior in seconds for each session across all conditions. More specifically, to determine the total number of bouts that occurred, experimenters summed the number of bout occurrences for each session for each condition. Additionally, to calculate mean bout instances, experimenters summed continuous instances of on-task behavior in seconds for each session within each condition and then divided by the total instances of bouts for that condition; ranges (minimum and maximum values) are also included in Supporting Information D. Instances of pausing were calculated in two ways. Within-session pausing, defined as the *absence* of responding or *nonengagement* of the target on-task behavior (see Craig et al., 2014, for a review

on pausing as an operant), was determined by calculating the difference between bouts of responding. That is, we calculated the amount of time that elapsed between each continuous bout of responding to identify the amount of time participants were not engaging in the target response (i.e., pauses in responding; Supporting Information A). In addition, instances of response pausing were calculated by totaling each occurrence of pausing within session for each session; this value was then aggregated to yield the total number of pausing instances for each experimental condition. We also examined within-session pausing following the delivery of tokens for accumulated-token sessions (Supporting Information C). To do this, we determined whether responding continued to occur or paused following the delivery of a token. If responding stopped following the delivery of a token, we calculated the amount of time that elapsed between token delivery and the next instance of on-task behavior. A *pause following token delivery* was counted if at least 1 s elapsed between the delivery of a token and initiation of on-task behavior. For example, if a token was delivered at Second 45 and the next bout of on-task behavior did not occur until Second 75, that would equate to a 30-s pause in responding in relation to token delivery. The data obtained from these within-session analyses may be beneficial for identifying potential variations in responding (e.g., bursts and pausing) on a second-by-second basis, particularly for duration-based behaviors with continuous and steady responding, which could provide important information about selecting one reinforcer arrangement over another.

Furthermore, we calculated the background probability of within-session pausing across conditions (see Supporting Information B) and the conditional probability of pausing instances following token delivery (see Supporting Information C). To calculate the background probability of pausing across all conditions, the experimenters first determined the mean duration of pausing for each session and aggregated this value for a given condition, and then this value was divided by the session duration (300 s). This allowed us to determine the probability of pausing occurring across all conditions and to assess whether certain conditions produced more or less pausing (Vollmer et al., 2001). To calculate the conditional probability of instances of pausing following token delivery, we determined the total number of pauses that occurred within 1 s of token delivery and divided by the total number of tokens delivered in the accumulated-token condition.

Discrimination test

After completing the comparison of the different schedules of reinforcement in the reinforcer evaluation, the experimenter conducted a discrimination test to ensure that the participant could differentiate between the contingencies associated with the color-correlated stimuli using procedures similar to those described by Frank-Crawford et al. (2019). The experimenter placed all four colored stimuli associated with each of the different conditions (baseline, synchronous, accumulated, accumulated tokens) in a row on the table equidistant from one another; the placement of the different materials was switched across each administration of the discrimination test (i.e., far left, far right, middle left, and middle right). The experimenter asked the participant to identify (by pointing to, touching, or naming a set of materials) the condition associated with a given contingency. Specifically, the experimenter asked the participant, "Show me the one where when you trace letters, X (extinction or one of the reinforcement contingencies) will happen" for all four conditions (i.e., baseline, synchronous, accumulated, accumulated tokens). If the participants correctly identified the contingencies associated with the color-correlated stimuli across all four conditions, they moved on to the preference assessment. If a participant did not correctly discriminate between the contingencies associated with the color-correlated stimuli, the experimenters would have conducted extended preexperimental exposure using the same training procedures previously described; they then would have reassessed discrimination using the discrimination-test procedures described above. However, all participants correctly identified the condition associated with a given contingency during the discrimination test. It is important to note that accuracy on the discrimination test allowed the experimenters to determine whether participants could discriminate the contingencies associated with color-correlated stimuli. Thus, the discrimination test alone does not prevent potential carryover effects across conditions.

Preference assessment

Following the discrimination test, we conducted a preference assessment using a concurrent-chains arrangement (Hanley et al., 2005; Herrnstein, 1964) to determine participant preference for the different conditions (i.e., synchronous, accumulated, accumulated token). The baseline materials were included in the preference assessment to serve as a control to ensure that participants were selecting the reinforcement condition they preferred the most and not just making a selection because the reinforcement conditions were the only ones available.

Preference-assessment sessions were conducted twice per day (i.e., one session in the morning and one in the afternoon). Prior to all preference-assessment sessions, the experimenter presented the participant with all four colored stimuli associated with each of the different conditions in a row on the table and reminded them of the contingencies associated with each set of materials. The placement of the different materials on the table was switched across each session. All participants had the opportunity to choose between all four of the experimental

conditions (i.e., baseline, synchronous, accumulated, accumulated token). After the experimenter reminded the participant of the contingencies associated with each set of materials, the experimenter asked them to pick their favorite by pointing to, touching, or naming a set of materials. The participant could only choose one set of materials associated with a specific condition per session. Once the participant made their selection, the experimenter then placed the chosen session materials on the table and conducted the chosen condition as described above.

RESULTS

Figure 1 depicts data for Willie, Remy, Angie, and Eleanor. During baseline, participants engaged in low levels (Willie, Remy, and Eleanor) or variable levels (Angie) of on-task behavior. During the reinforcement phase, all participants engaged in higher and more stable levels of on-task behavior during the synchronous condition. For Willie, few reinforcement effects were observed during the accumulated and accumulated-token conditions; however, the accumulated-token condition produced somewhat higher levels of on-task behavior. For Remy and Angie, variable levels of on-task behavior with little to no differentiation between accumulated and accumulated-token conditions was observed; furthermore, levels for both suggested relatively less robust reinforcement effects relative to the synchronous condition. For Eleanor, the accumulated and accumulated-token conditions resulted in an increase in levels of on-task behavior relative to baseline levels of responding; however, on-task behavior in these conditions was more variable than it was in the synchronous condition.

Figure 2 depicts data for David, Garrett, and Louise. During baseline, participants engaged in low levels (David and Garrett) or variable levels (Louise) of on-task behavior. During the reinforcement phase, David and Garrett engaged in high levels of on-task behavior across all three reinforcement conditions. Louise engaged in higher levels of on-task behavior during both synchronous and accumulated conditions; however, the synchronous condition produced the most stable levels of on-task behavior. Additionally, Louise engaged in variable levels of on-task behavior in the accumulated-token condition, suggesting a less robust reinforcement effect relative to the synchronous and accumulated conditions.

Figures 3, 4, 5, and 6 depict outcomes for the within-session analyses to examine bouts of responding, within-session pausing and pausing following token delivery, and background probability of pausing for all participants. For a summary of the within-session analyses for response-pausing duration and instances, please refer to Supporting Information A. Overall, the results of the within-session pausing analysis, specifically the pausing-duration analysis, showed lower pause durations in the synchronous condition than in the accumulated and accumulated-token conditions across all participants

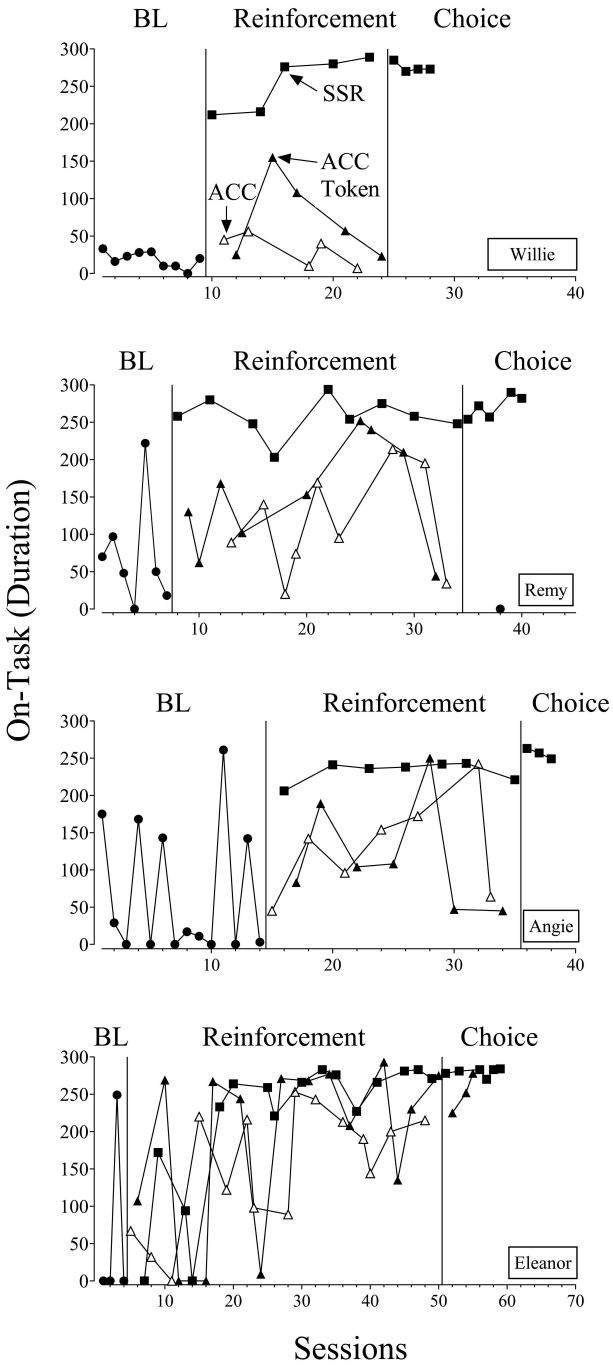

FIGURE 1 On-task data for Willie, Remy, Angie, and Eleanor. BL = baseline; SSR = synchronous reinforcement; ACC = accumulated reinforcement; ACC Token = accumulated token.

(Supporting Information A). Additionally, the synchronous condition had the lowest background probability of pausing across all participants relative to baseline, accumulated, and accumulated-token conditions (Supporting Information B). Notably, the mean instances of pausing varied across participants across conditions and did not show a clear pattern (Supporting Information A). Furthermore, the results showed that the conditional probability of pausing instances (absence of responding) following token delivery

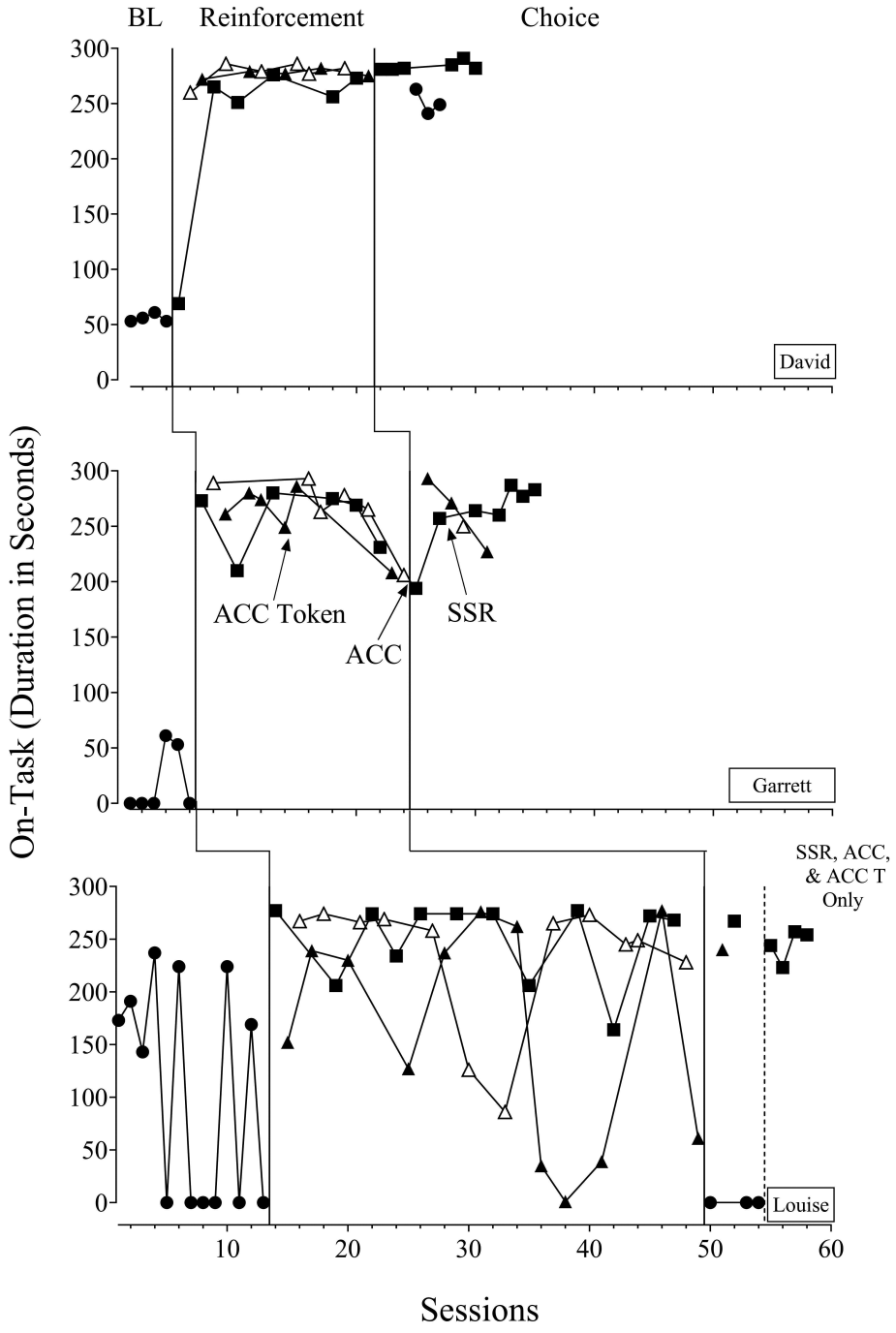

FIGURE 2 On-task data for David, Garrett, and Louise. BL = baseline; SSR = synchronous reinforcement; ACC = accumulated reinforcement; ACC Token = accumulated token; ACC T = accumulated token.

was low (i.e., <1; Supporting Information C). Moreover, the mean pausing duration following token delivery was less than 7 s for all participants (see Figures 3–6 for second-by-second graphs and Supporting Information C). Furthermore, only one instance of pausing following token delivery occurred in the accumulated-token condition (see Supporting Information C) and the synchronous condition produced longer mean durations of responding relative to baseline, accumulated, and accumulated-token conditions (see Supporting Information D).

During the preference phase, all seven participants chose the synchronous condition the most and engaged in high levels of on-task behavior during those sessions. However, during initial preference-assessment sessions, Louise chose the baseline condition and did not engage in on-task behavior during those sessions even though results of the discrimination test demonstrated that she could discriminate between the contingencies associated with the color-correlated stimuli. Given that the purpose of the preference assessment was to assess preference for

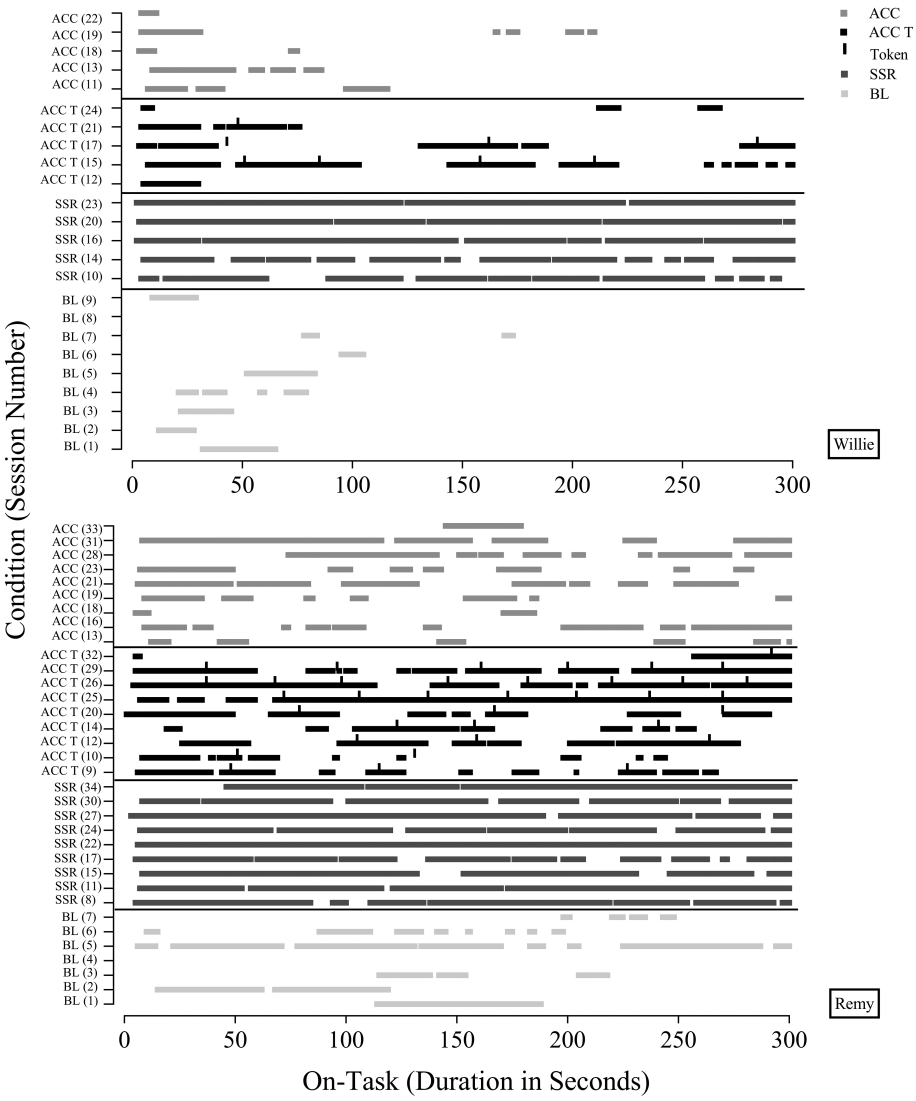

FIGURE 3 Within-session analyses data for Willie and Remy. On-task behavior is depicted by the shaded area, the black tick marks denote token delivery, and any area that is not shaded (i.e., blank) indicates on-task behavior was not occurring. BL = baseline; SSR = synchronous reinforcement; ACC = accumulated reinforcement; ACC T = accumulated token.

the reinforcement conditions, we conducted a modified preference assessment using the same concurrent-chains arrangement as previously described, with the exception that we removed the baseline condition materials from the array and only presented materials for the reinforcement conditions (i.e., synchronous, accumulated, and accumulated token). Following this modification, Louise exclusively chose the synchronous condition and engaged in high levels of on-task behavior during those sessions.

DISCUSSION

Overall, the results of the current study replicated Diaz de Villegas et al. (2020), showing that synchronous reinforcement was effective in increasing levels of on-task behavior for all seven participants and was preferred by all seven participants. Furthermore, the results showed that synchronous reinforcement was more effective than were accumulated- and accumulated-token-reinforcement conditions for increasing on-task behavior for three of seven participants (Willie, Remy, and Angie). Additionally, all three reinforcement schedules (synchronous, accumulated, and accumulated token) were equally effective for increasing on-task behavior for two of seven participants (David and Garrett). Moreover, synchronous and accumulated-token reinforcement were similarly effective for one participant (Eleanor), and synchronous and accumulated reinforcement were similarly effective for another participant (Louise).

The results of the within-session analyses comparing bout duration and instances, pausing duration and instances, pausing following token delivery, and probability analyses yielded interesting findings. Overall, the results

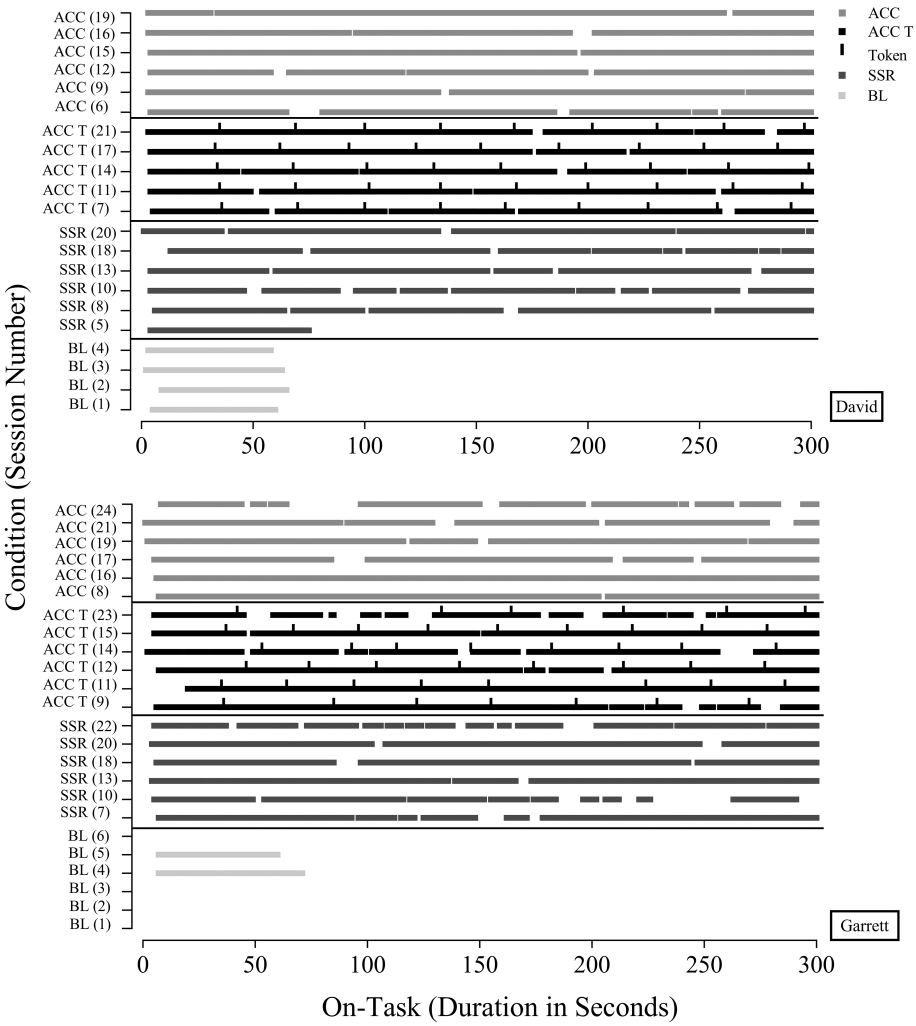

FIGURE 4 Within-session analyses data for David and Garrett. On-task behavior is depicted by the shaded area, the black tick marks denote token delivery, and any area that is not shaded (i.e., blank) indicates on-task behavior was not occurring. BL = baseline; SSR = synchronous reinforcement; ACC = accumulated reinforcement; ACC T = accumulated token.

showed that the duration of pausing and the probability of pausing were lower in the synchronous condition relative to baseline, accumulated, and accumulated-token conditions. Additionally, longer bouts of responding occurred in the synchronous condition for most participants. Finally, little to no pausing following token delivery occurred in the accumulated-token condition and the duration of pausing was low, suggesting that token delivery did not disrupt responding.

The results of the current study replicate those of Diaz de Villegas et al. (2020) in that synchronous reinforcement was more effective than accumulated reinforcement for some participants and was preferred by all participants. The synchronous condition may have been more effective and preferred because reinforcer delivery was immediate with the onset of the response and the reinforcing consequence was removed with the offset of the response, which may have functioned as negative punishment. Furthermore, the ongoing delivery of reinforcement while responding may have decreased aversive aspects of the task (Carr et al., 1980; Lalli et al., 1999; Lomas et al., 2010; Wallace et al., 2012). Lower levels of on-task behavior observed during both accumulated-reinforcement conditions may be due to the absence of these factors or due to delayed reinforcer delivery (Lattal, 2010; Miltenberger, 2016). It may also be due to adventitious reinforcement of off-task behavior (Lattal & Gleeson, 1990; Williams, 1976). That is, across both accumulated-reinforcement conditions, reinforcer access was delivered at the end of the session and matched the duration of on-task behavior during the session regardless of whether on-task behavior occurred at the end of the session. Furthermore, if a token was not delivered at the end of a session, its association with backup-reinforcer access may have been eliminated and decreased the efficacy of tokens as conditioned reinforcers (Hackenberg, 2009; Kazdin, 1982).

Additionally, the results showed that all three reinforcement conditions were effective in increasing on-task

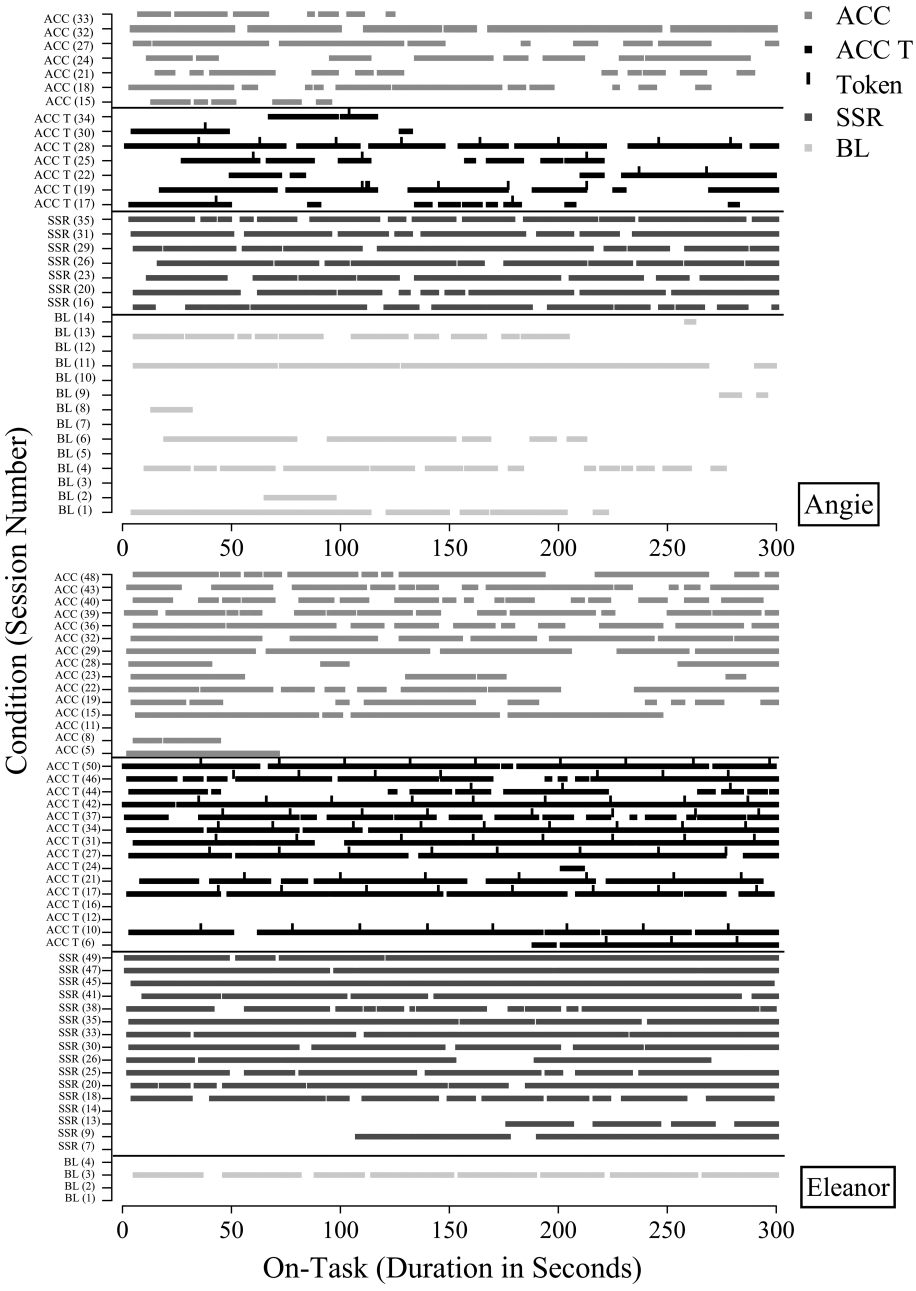

FIGURE 5 Within-session analyses data for Angie and Eleanor. On-task behavior is depicted by the shaded area, the black tick marks denote token delivery, and any area that is not shaded (i.e., blank) indicates on-task behavior was not occurring. BL = baseline; SSR = synchronous reinforcement; ACC = accumulated reinforcement; ACC T = accumulated token.

behavior for two participants (David and Garrett), which is unlikely to be due to lack of discrimination because both participants performed well on the discrimination test. As discussed by Diaz de Villegas et al. (2020), efficacy across these three conditions might be due to fluent work schedules and ongoing access to programmed reinforcement (Fienup et al., 2011; Pitts, 2014). Future research should compare these schedules to disfluent work and reinforcement schedules to determine the importance of these variables for behavior change.

The results of the current study also showed that synchronous and accumulated reinforcement were similarly effective for one participant (Louise), whereas the accumulated-token condition resulted in more variable responding. Although the results of the within-session analyses showed that token delivery was not disruptive, tokens may not have functioned as conditioned reinforcers or effectively supported higher and more stable levels of responding for Louise (Frank-Crawford et al., 2012). Additionally, the results of the initial preference assessment showed that Louise chose the baseline condition and

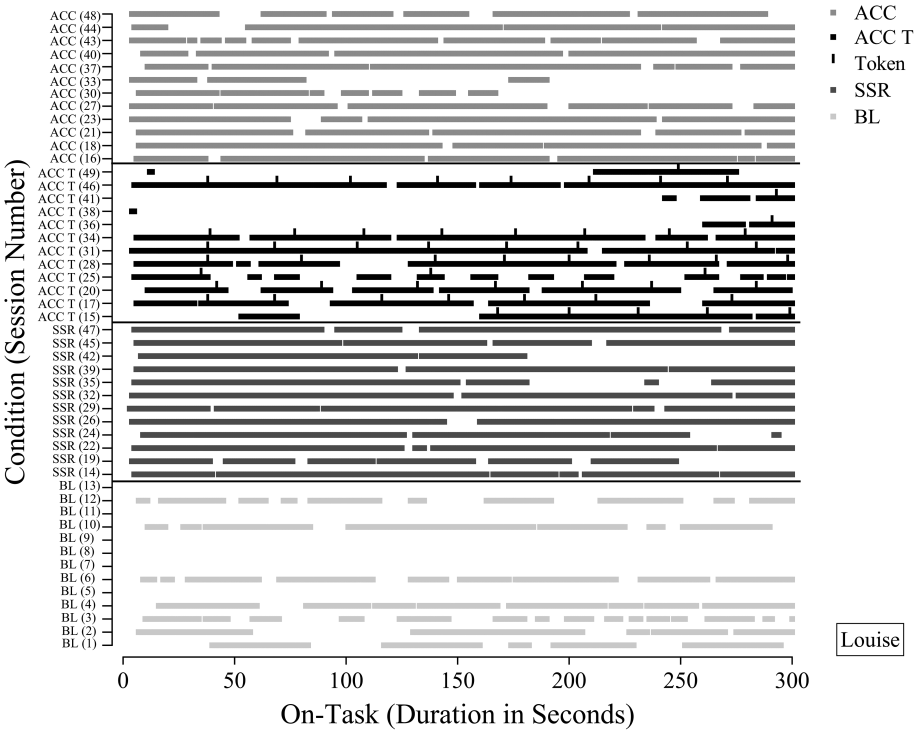

FIGURE 6 Within-session analyses data for Louise. On-task behavior is depicted by the shaded area, the black tick marks denote token delivery, and any area that is not shaded (i.e., blank) indicates on-task behavior was not occurring. BL = baseline; SSR = synchronous reinforcement; ACC = accumulated reinforcement; ACC T = accumulated token.

did not engage in on-task behavior. When baseline was removed as a choice option, Louise exclusively chose the synchronous condition. Louise's initial choice of the baseline condition may have been due to overall longer session durations for both accumulated conditions. However, anecdotally, Louise reported that she "just wanted to draw … and did not want to trace letters."

Furthermore, the results of the within-session analyses extended Diaz de Villegas et al. (2020). Overall, shorter durations of pausing and more continuous and longer bouts of on-task behavior during the synchronous condition were observed. However, quantitative analyses showed that mean bout durations were not highest during the synchronous condition for all participants. Notably, little to no pausing occurred following token delivery, suggesting that token delivery did not have a disruptive effect on responding. These findings may help inform the selection of certain reinforcer arrangements over others. In the future, researchers should collect and analyze data on the rate of responding during session and accurate task completion, as these are important and socially valid aspects of preacademic and academic tasks to determine the degree to which these behaviors are influenced by these schedule arrangements.

Similar to Diaz de Villegas et al. (2020), some limitations of the current study may be the longer total session duration for accumulated and accumulated-token conditions than for synchronous reinforcement and the delivery of attention not being perfectly synchronized with on-task behavior. Although session durations varied, participants did not state that they chose a condition or that they did not engage in on-task behavior to decrease time in the session room and return to the classroom.

The current study has additional limitations. First, we did not equate reinforcer density across the three reinforcement conditions because density was determined by the participant's own responding. Thus, within the context of the preference assessment, the density of reinforcement could have influenced participant preference. For example, participants may have chosen the condition that produced the greatest magnitude of reinforcement during the reinforcer evaluation. In the future, researchers should conduct a preference assessment before and after the reinforcer evaluation to assess whether preference(s) change after a history with each schedule.

Second, the accumulated-token condition had several methodological limitations that may have affected the outcomes of the current study. For example, the presession exposure for the accumulated-token condition may have been insufficient for teaching the token-production schedule, exchange-production schedule, and token-exchange schedule. Although participants had a history with tokens in their preschool classrooms, the degree to which those tokens were trained, the procedural fidelity of their implementation, and whether exposure to a token economy in the classroom setting generalized to sessions are unknown. The absence of formal token training is

important to note; however, this practice is not inconsistent with those reported in practice in clinical and instructional settings (Fernandez et al., 2023). Tokens may not have functioned as conditioned reinforcers such that their delivery bridged the delay between engaging in on-task behavior and reinforcer delivery. Additionally, the 30-s response requirement may have been too thin of a schedule to support and effectively reinforce responding. In the future, researchers should decrease the response requirement for the token-production schedule to assess whether this would better support responding. Furthermore, the tokens used may not have sufficiently signaled accumulation of reinforcer access. To remedy this limitation, researchers might consider signaling reinforcer accumulation by delivering tokens or a stimulus akin to "tokens" on a second-by-second basis or using a visual timer or visual "bar" that increases in size to show they are earning more time. Additionally, it is important to note that exposure trials for the accumulated-token condition did not match the contingencies during the session. That is, during presession exposure participants were prompted to trace for 10 s to earn one token and then prompted to trace for another 10 s to earn a second token that resulted in 20 s of reinforcer access. However, during the accumulated-token sessions, tokens were delivered contingent on 30 s of cumulative on-task behavior engagement. This discrepancy between the presession exposure and the session contingency may have influenced responding.

Finally, the inclusion of music as the reinforcing stimulus delivered across experimental conditions might be a limitation. Previous research has shown that music complements or enhances vigilance tasks (Hume & Crossman, 1992; Kiss & Linnell, 2021). Given this, the synchronous-reinforcement condition may have produced more robust effects because the delivery of music made the task less aversive. It is possible that other stimuli would not function as complementary reinforcers (Green & Freed, 1993; Reed et al., 2013) and produce robust effects. Similarly, the tracing task used may have been easy and required low response effort to complete. Researchers should include more difficult or aversive tasks to determine whether this variable is sensitive to the reinforcer arrangements used in the current study.

There are various avenues for future research on synchronous schedules. Researchers should evaluate the efficacy of synchronous reinforcement across populations, behaviors, and environments. For example, synchronous reinforcement could be evaluated for increasing engagement or tolerance with activities of daily living (e.g., toothbrushing) and transition behaviors (i.e., transitioning from high- to low-preferred activities). Additionally, researchers could evaluate synchronous reinforcement within a group contingency to address behaviors (e.g., on-task behavior, physical activity) for groups of individuals in classrooms or group homes. Researchers should also determine procedures for promoting maintenance and generalization of behavior change following synchronous reinforcement. Furthermore, researchers should examine ways to fade synchronous reinforcement to assess the durability of reinforcer effects when thinning the schedule of reinforcement.

Future research might also involve comparing synchronous reinforcement with other common schedules of reinforcement. In a recent study, Hardesty et al. (2023), compared synchronous reinforcement and noncontingent reinforcement for increasing on-task behavior with three school-aged children. The results of their study showed that synchronous reinforcement was more effective for all three participants, suggesting that the synchronous-reinforcement contingency was necessary for behavior change (i.e., the mere presence of music did not maintain high levels of responding). However, comparisons of synchronous reinforcement with other schedules are warranted under various contexts. For example, researchers might compare synchronous reinforcement with other episodic schedules that are typically found in applied contexts such as ratio or interval schedules that involve disfluent work schedules (see Fienup et al., 2011; Ward-Horner, 2014, 2017, for studies on fluent and disfluent work schedules) to determine the conditions under which these schedules are likely to be most effective.

In summary, the results of the current study did not suggest that tokens enhanced the efficacy of accumulated conditions, which was surprising given the research suggesting the utility of signals during delayed-reinforcer arrangements. However, the overall results suggest that synchronous reinforcement involves a highly effective contingency for behavior change, and thus additional research is needed to determine the applicability of this schedule as well as that of other schedules of covariation in assessment and intervention for behavior change. Finally, the current study extended the literature on schedules of covariation, specifically synchronous schedules, and added to the small literature comparing schedules of covariation (i.e., nonepisodic) with episodic schedules.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to disclose regarding the current manuscript.

DATA AVAILABILITY STATEMENT

Supporting Information includes additional data summarizing within-session analyses: specifically, within-session

analyses of response-pausing duration and instances, background probability of pausing, conditional probability of pausing in the accumulated-token condition, and analysis of bouts of responding.

ETHICS APPROVAL

This study received Institutional Review Board approval and was conducted in accordance with established ethical guidelines for the treatment of human participants. Caregivers provided informed consent for all participants. Prior to all sessions, assent from the participant was required.

REFERENCES

Biddiss, E., & Irwin, J. (2010). Active video games to promote physical activity in children and youth. *Archives of Pediatrics & Adolescent Medicine*, *164*(7), 664–672. https://doi.org/10.1001/archpediatrics.2010.104

Carr, E. G., Newsom, C. D., & Binkoff, J. A. (1980). Escape as a factor in the aggressive behavior of two retarded children. *Journal of Applied Behavior Analysis*, *13*(1), 101–117. https://doi.org/10.1901/jaba.1980.13-101

Craig, A. R., Lattal, K. A., & Hall, E. G. (2014). Pausing as an operant: Choice and discriminated responding. *Journal of the Experimental Analysis of Behavior*, *101*(2), 230–245. https://doi.org/10.1002/jeab.73

DeLeon, I. G., Chase, J. A., Frank-Crawford, M. A., Carreau-Webster, A. B., Triggs, M. M., Bullock, C. E., & Jennett, H. K. (2014). Distributed and accumulated reinforcement arrangements: Evaluations of efficacy and preference. *Journal of Applied Behavior Analysis*, *47*(2), 293–313. https://doi.org/10.1002/jaba.116

Diaz de Villegas, S. C., Dozier, C. L., Jess, R. L., & Foley, E. A. (2020). An evaluation of synchronous reinforcement for increasing on-task behavior in preschool children. *Journal of Applied Behavior Analysis*, *53*(3), 1660–1673. https://doi.org/10.1002/jaba.696

Faith, M. S., Berman, N., Heo, M., Pietrobelli, A., Gallagher, D., Epstein, L. H., Eiden, M. T., & Allison, D. B. (2001). Effects of contingent television on physical activity and television viewing in obese children. *Pediatrics*, *107*(5), 1043–1048. https://doi.org/10.1542/peds.107.5.1043

Fernandez, N., Argueta, T., & DeLeon, I. G. (2023). Common practices used to establish and implement token economies in clinical and instructional settings: A survey of BACB certificants. *Behavior Analysis in Practice*, *16*(4), 1151–1162. https://doi.org/10.1007/s40617-023-00800-5

Ferster, C. B., & Skinner, B. F. (1957). *Schedules of reinforcement*. Appleton-Century-Crofts. https://doi.org/10.1037/10627-000

Fienup, D. M., Ahlers, A. A., & Pace, G. (2011). Preference for fluent versus disfluent work schedules. *Journal of Applied Behavior Analysis*, *44*(4), 847–858. https://doi.org/10.1901/jaba.2011.44-847

Frank-Crawford, M. A., Borrero, J. C., Newcomb, E. T., Chen, T., & Schmidt, J. D. (2019). Preference for and efficacy of accumulated and distributed response-reinforcer arrangements during skill acquisition. *Journal of Behavioral Education*, *28*(2), 227–257. https://doi.org/10.1007/s10864-018-09312-7

Frank-Crawford, M. A., Borrero, J. C., Nguyen, L., Leon-Enriquez, Yanerys, & DeLeon, I. G. (2012). Disruptive effects of contingent food on high-probability behavior. *Journal of Applied Behavior Analysis*, *45*(1), 143–148. https://doi.org/10.1901/jaba.2012.45-143

Friedlander, B. Z. (1966). Three manipulanda for the study of human infants' operant play. *Journal of the Experimental Analysis of Behavior*, *9*(1), 47–49. https://doi.org/10.1901/jeab.1966.9-47

Green, L., & Freed, D. E. (1993). The substitutability of reinforcers. *Journal of the Experimental Analysis of Behavior*, *60*(1), 141–158. https://doi.org/10.1901/jeab.1993.60-141

Hackenberg, T. D. (2009). Token reinforcement: A review and analysis. *Journal of the Experimental Analysis of Behavior*, *91*(2), 257–286. https://doi.org/10.1901/jeab.2009.91-257

Hanley, G. P., Piazza, C. C., Fisher, W. W., & Maglieri, K. A. (2005). On the effectiveness of and preference for punishment and extinction components of function-based interventions. *Journal of Applied Behavior Analysis*, *38*(1), 51–65. https://doi.org/10.1901/jaba.2005.6-04

Hardesty, E. M., Lerman, D. C., & Hardee, J. L. (2023). A comparison of synchronous and noncontingent stimulus delivery on task engagement. *Journal of Applied Behavior Analysis*, *56*(3), 664–673. https://doi.org/10.1002/jaba.986

Herrnstein, R. J. (1964). Secondary reinforcement and rate of primary reinforcement. *Journal of the Experimental Analysis of Behavior*, *7*(1), 27–36. https://doi.org/10.1901/jeab.1964.7-27

Horowitz, F. D. (1974a). Infant attention and discrimination: Methodological and substantive issues. *Monographs of the Society for Research in Child Development*, *39*(5/6), 1–15. https://doi.org/10.2307/1165968

Horowitz, F. D. (1974b). Discussion and conclusions. *Monographs of the Society for Research in Child Development*, *39*(5/6), 105–115. https://doi.org/10.2307/1165976

Hume, K. M., & Crossman, J. (1992). Musical reinforcement of practice behaviors among competitive swimmers. *Journal of Applied Behavior Analysis*, *25*(3), 665–670. https://doi.org/10.1901/jaba.1992.25-665

Kazdin, A. E. (1982). The token economy: A decade later. *Journal of Applied Behavior Analysis*, *15*(3), 431–445. https://doi.org/10.1901/jaba.1982.15-431

Kiss, L., & Linnell, K. J. (2021). The effect of preferred background music on task-focus in sustained attention. *Psychological Research*, *85*(6), 2313–2325. https://doi.org/10.1007/s00426-020-01400-6

Lalli, J. S., Vollmer, T. R., Progar, P. R., Wright, C., Borrero, J., Daniel, D., Hoffner Barthold, C., Tocco, K., & May, W. (1999). Competition between positive and negative reinforcement in the treatment of escape behavior. *Journal of Applied Behavior Analysis*, *32*(3), 285–296. https://doi.org/10.1901/jaba.1999.32-285

Lattal, K. A. (2010). Delayed reinforcement of operant behavior. *Journal of the Experimental Analysis of Behavior*, *93*(1), 129–139. https://doi.org/10.1901/jeab.2010.93-129

Lattal, K. A., & Gleeson, S. (1990). Response acquisition with delayed reinforcement. *Journal of Experimental Psychology: Animal Behavior Processes*, *16*(1), 27–39. https://doi.org/10.1037/0097-7403.16.1.27

Lattal, K. A., & Neef, N. A. (1996). Recent reinforcement-schedule research and applied behavior analysis. *Journal of Applied Behavior Analysis*, *29*(2), 213–230. https://doi.org/10.1901/jaba.1996.29-213

Lerman, D. C., Iwata, B. A., Shore, B. A., & Kahng, S. W. (1996). Responding maintained by intermittent reinforcement: Implications for the use of extinction with problem behavior in clinical settings. *Journal of Applied Behavior Analysis*, *29*(2), 153–171. https://doi.org/10.1901/jaba.1996.29-153

Leuba, C., & Friedlander, B. Z. (1968). Effects of controlled audiovisual reinforcement on infants' manipulative play in the home. *Journal of Experimental Child Psychology*, *6*(1), 87–99. https://doi.org/10.1016/0022-0965(68)90074-X

Lomas, J. E., Fisher, W. W., & Kelley, M. E. (2010). The effects of variable-time delivery of food items and praise on problem behavior reinforced by escape. *Journal of Applied Behavior Analysis*, *43*(3), 425–435. https://doi.org/10.1901/jaba.2010.43-425

Mace, F. C., Pritchard, D., & Penney, Heather. (2021). Schedules of reinforcement. In W. W. Fisher, C. C. Piazza, & H. S. Roan (Eds.), *Handbook of applied behavior analysis* (2nd ed., pp. 58–77). The Guildford Press.

McHugh, C. L., Dozier, C. L., Diaz de Villegas, S. C., & Kanaman, N. A. (2022). Using synchronous reinforcement to increase mask wearing in adults with intellectual and developmental disabilities. *Journal of Applied Behavior Analysis*, *55*(4), 1157–1171. https://doi.org/10.1002/jaba.950

Miltenberger, R. G. (2016). *Behavior modification: Principles and procedures* (6th ed.). Cengage Learning.

Morgan, D. L. (2010). Schedules of reinforcement at 50: A retrospective appreciation. *The Psychological Record*, *60*(1), 151–172. https://doi.org/10.1007/BF03395699

Pelaez-Nogueras, M., Field, T., Gewirtz, J. L., Cigales, M., Gonzalez, A., Sanchez, A., & Richardson, S. C. (1997). The effect of systematic stroking versus tickling and poking on infant behavior. *Journal of Applied Developmental Psychology*, *18*(2), 169–178. https://doi.org/10.1016/S0193-3973(97)90034-4

Pelaez-Nogueras, M., Gewirtz, J. L., Field, T., Cigales, M., Malphurs, J., Clasky, S., & Sanchez, A. (1996). Infants' preference for touch stimulation in face-to-face interactions. *Journal of Applied Developmental Psychology*, *17*(2), 199–213. https://doi.org/10.1016/S0193-3973(96)90025-8

Pitts, R. C. (2014). Reconsidering the concept of behavioral mechanisms of drug action. *Journal of the Experimental Analysis of Behavior*, *101*(3), 422–441. https://doi.org/10.1002/jeab.80

Ramey, C. T., Hieger, L., & Klisz, D. (1972). Synchronous reinforcement of vocal responses in failure-to-thrive infants. *Child Development*, *43*(4), 1449–1455. https://doi.org/10.2307/1127533

Reed, D. D., Niileksela, C. R., & Kaplan, B. A. (2013). Behavioral economics. *Behavior Analysis in Practice*, *6*(1), 34–54. https://doi.org/10.1007/BF03391790

Rovee-Collier, C. K., & Gekoski, M. J. (1979). The economics of infancy: A review of conjugate reinforcement. *Advances in Child Development and Behavior*, *13*, 195–255. https://doi.org/10.1016/S0065-2407(08)60348-1

Saunders, M. D., Questad, K. A., Kedziorski, T. L., Boase, B. C., Patterson, E. A., & Cullinan, T. B. (2001). Unprompted mechanical switch use in individuals with severe multiple disabilities: An evaluation of the effects of body position. *Journal of Developmental and Physical Disabilities*, *13*(1), 27–39. https://doi.org/10.1023/A:1026505332347

Saunders, M. D., & Saunders, R. R. (2011). Innovation of a reinforcer preference assessment with the difficult to test. *Research in Developmental Disabilities*, *32*(5), 1572–1579. https://doi.org/10.1016/j.ridd.2011.01.049

Saunders, M. D., Timler, G. R., Cullinan, T. B., Pilkey, S., Questad, K. A., & Saunders, R. R. (2003). Evidence of contingency awareness in people with profound multiple impairments: Response duration versus response rate indicators. *Research in Developmental Disabilities*, *24*(4), 231–245. https://doi.org/10.1016/S0891-4222(03)00040-4

Siqueland, E. R. (1968). Reinforcement patterns and extinction in human newborns. *Journal of Experimental Child Psychology*, *6*(3), 431–442. https://doi.org/10.1016/0022-0965(68)90124-0

Siqueland, E. R., & Lipsitt, L. P. (1966). Conditioned head-turning in human newborns. *Journal of Experimental Child Psychology*, *3*(4), 356–376. https://doi.org/10.1016/0022-0965(66)90080-4

Smith, K. U., Zwerg, C., & Smith, N. J. (1963). Sensory-feedback analysis of infant control of the behavioral environment. *Perceptual and Motor Skills*, *16*(3), 725–732. https://doi.org/10.2466/pms.1963.16.3.725

Striefel, S., & Smeets, P. M. (1974). TV preference as a technique for selection of reinforcers. *Psychological Reports*, *35*(1), 107–113. https://doi.org/10.2466/pr0.1974.35.1.107

Vollmer, T. R., Borrero, J. C., & Wright, C. S., Van Camp, C., & Lalli, J. S. (2001). Identifying possible contingencies during descriptive analyses of severe behavior disorders. *Journal of Applied Behavior Analysis*, *34*(3), 269–287. https://doi.org/10.1901/jaba.2001.34-269

Wallace, M. D., Iwata, B. A., Hanley, G. P., Thompson, R. H., & Roscoe, E. M. (2012). Noncontingent reinforcement: A further examination of schedule effects during treatment. *Journal of Applied Behavior Analysis*, *45*(4), 709–719. https://doi.org/10.1901/jaba.2012.45-709

Ward-Horner, J. C., Cengher, M., Ross, R. K., & Fienup, D. M. (2017). Arranging response requirements and the distribution of reinforcers: A brief review of preference and performance outcomes. *Journal of Applied Behavior Analysis*, *50*(1), 181–185. https://doi.org/10.1002/jaba.350

Ward-Horner, J. C., Pittenger, A., Pace, G., & Fienup, D. M. (2014). Effects of reinforcer magnitude and distribution on preference for work schedules. *Journal of Applied Behavior Analysis*, *47*(3), 623–627. https://doi.org/10.1002/jaba.133

Weisberg, P., & Rovee-Collier, C. (1998). Behavioral process of infants and young children. In K. A. Lattal & M. Perone (Eds.), *Handbook of research methods in human operant behavior* (pp. 325–370). Plenum Press. https://doi.org/10.1007/978-1-4899-1947-2

Williams, B. A. (1976). The effects of unsignalled delayed reinforcement. *Journal of the Experimental Analysis of Behavior*, *26*(3), 441–449. https://doi.org/10.1901/jeab.1976.26-441

Williams, D. C., & Johnston, J. M. (1992). Continuous versus discrete dimensions of reinforcement schedules: An integrative analysis. *Journal of the Experimental Analysis of Behavior*, *58*(1), 205–228. https://doi.org/10.1901/jeab.1992.58-205

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A

A.1 | Condition-specific instructions

A.1.1. | Baseline

"This is the white condition. Here are sheets for tracing [letters] and here are some sheets for drawing. If you have finished one page of tracing [letters], you can move to the next page. During the session, when you trace [letters], nothing will happen."

A.1.2. | Synchronous reinforcement (SSR)

"This is the blue condition. Here are sheets for tracing [letters], and here are some sheets for drawing. If you have finished one page of tracing [letters], you can move to the next page. When you trace [letters], you will get to listen to (the three chosen songs) and talk with me. When

you stop tracing [letters], (the three chosen songs) will turn off and we will stop talking."

A.1.3. | Accumulated reinforcement (ACC)

"This is the red condition. Here are sheets for tracing [letters], and here are some sheets for drawing. If you have finished one page of tracing [letters], you can move to the next page. For however long you trace [letters], you will get to listen to (the three chosen songs) and talk with me at the end of the session. If you stop tracing, you will not get to listen to (the three chosen songs) or talk with me for the entire time after tracing."

A.1.4. | Accumulated reinforcement tokens (ACC w/tokens)

"This is the yellow condition. Here are sheets for tracing [letters], and here are some sheets for drawing. If you have finished one page of tracing [letters], you can move to the next page. For however long you trace [letters], you will get to listen to (the three chosen songs) and talk with me at the end of the session. If you stop tracing, you will not get to listen to (the three chosen songs) and talk with me for the entire time after tracing. When you are tracing, you will also get tokens.