An Evaluation of Synchronous Reinforcement for Increasing On-task Behavior in Preschool Children

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Abstract

Schedules of covariation are those in which changes in a specific response class (e.g., rate, intensity, or duration of behavior) produce corresponding changes in a reinforcer (e.g., rate, intensity, or duration; Williams & Johnston, 1992). Furthermore, these schedules involve the behavior and reinforcer fluctuating or varying together. A synchronous-reinforcement schedule is a type of schedule of covariation in which the onset and offset of the reinforcer covaries with the onset and offset of the behavior (Ramey, Heiger, & Klisz, 1972; Weisberg & Rovee-Collier, 1998). The purpose of this study was to evaluate the efficacy of and preference for a synchronous-reinforcement schedule for increasing on-task behavior in preschoolers. Specifically, we compared the effects of a synchronous-reinforcement schedule to one in which continuous access to stimuli were delivered at the end of the session and yoked to the duration of on-task behavior that occurred during the session. Thus, in both conditions, continuous access to stimuli was delivered for the duration of time in which on-task behavior occurred; the only difference was whether the stimuli were delivered based on moment-to-moment changes in the occurrence of on-task behavior or at end of the session. Results showed the synchronous-reinforcement schedule was more effective for increasing on-task behavior and more preferred for most participants. Results are discussed in light of potential mechanisms by which the synchronous schedule was more effective and preferred and areas for future research.

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Schedules of reinforcement are a set of procedures or rules that specify the conditions under which a response or a set of responses produce reinforcing consequences (Ferster & Skinner, 1957), with different schedules of reinforcement producing different response patterns (Pierce & Cheney, 2013). Much research has been conducted evaluating and comparing the effects of common schedules of reinforcement (e.g., fixed ratio, variable ratio, fixed interval, variable interval), and research has shown consistent outcomes of these schedules with different organisms, behaviors, and reinforcers (Pierce & Cheney). A far less studied group of schedules termed "schedules of covariation" are schedules in which changes in a specific response class produce corresponding changes in a reinforcer (Williams & Johnston, 1992). That is, some parameter of the behavior (e.g., rate, intensity, duration) determines some dimension of reinforcement (e.g., rate, intensity, duration). Thus, schedules of covariation are similar to a continuous schedule in that each response results in reinforcement; however, they differ from a continuous schedule because the behavior and reinforcer fluctuate, or covary together.

One type of schedule of covariation is the conjugate-reinforcement schedule in which the rate, amplitude, or intensity of behavior directly controls some aspect of reinforcement (e.g., magnitude, intensity, or amplitude of reinforcement) on a moment-to-moment basis (Lewis, 1973; Lindsley, 1962; MacAleese, Ghezzi, & Rapp, 2015; Rapp, 2008). More specifically, the reinforcing consequences continuously covary in proportion to changes in the behavior (Rovee-Collier & Gekoski, 1979). For example, in driving a car, the intensity and force of pressing the accelerator (behavior) is directly proportional to the speed and movement of the car (reinforcement). Similarly, when playing the drums, the force used to strike the drumsticks against the drum set determines the intensity of the sound. Furthermore, the intensity of a child screaming or crying may determine the magnitude of adult attention.

Lindsley (1957) initially developed the conjugate reinforcement preparation as a tool to study adult sleep cycles. To do so, sleep deprived subjects wore a helmet with earphones fitted inside that would play a tone. Subjects could press a hand-held device to reduce the volume of the tone that played continuously. Therefore, the subject's responding directly controlled the intensity of the tone. This preparation allowed Lindsley to study adult sleep patterns by evaluating the effects of sleep deprivation on sleep onset and duration (i.e., latency to response cessation and the duration of response cessation). After that initial use, Lindsley went on to use the conjugate-schedule paradigm to study anesthesia recovery (Lindsley, Hobika, & Etsen, 1961) and the depth of a coma after electroshock therapy (Lindsley & Conran, 1958/1962) using similar procedures. In both studies, subjects could engage in a response (touching index finger to thumb or squeezing a palm switch) to reduce the intensity of the auditory tone. Results from both studies demonstrated that responding was sensitive to changes in the intensity of the tone. Furthermore, both studies demonstrated the sensitivity of this preparation in studying the effects of anesthesia on the duration of anesthesia recovery (Lindsley et al., 1961) and electroshock therapy on duration and depth of coma (Lindsley & Conran, 1958/1962).

Since Lindley's original work in this area, the conjugate-reinforcement paradigm has been used to study a variety of behaviors and psychological phenomena. The most common are (a) infant operant behavior and various psychological phenomena regarding infants such as infant exploratory behavior (e.g., Rovee & Rovee, 1969), positive behavioral contrast (e.g., Rovee-Collier & Capatides, 1979), infant play behavior (e.g., panel pressing; Lipsitt, Penderson, & DeLucia, 1966), (b) the reinforcing efficacy of various stimuli including social reinforcers (e.g., Edwards & Peek, 1970; Lindsley, 1963; Lovitt, 1967; McKirdy & Rovee, 1978; Mira, 1969; Mira, 1970; Siqueland & DeLucia, 1969), and (c) the effects on increasing or decreasing target behavior such as work output (e.g., Greene & Hoats, 1969), physical activity (e.g., Caouette & Reid, 1991; Dozier, Iwata, Thompson, & Neidert, 2007; Lancioni et al., 2003), and motor activity (e.g., Switzky & Haywood, 1973).

Several studies have shown the utility of the conjugate-reinforcement paradigm for determining reinforcer efficacy. For example, Edwards and Peek (1970) evaluated whether radio listening was a reinforcer for two adult subjects using a conjugate-reinforcement paradigm. That is, subjects pressed a hand switch to directly control the volume (intensity) of the radio. Thus, the volume of the radio was a direct function of the rate of pressing, and responding at a particular rate maintained the subject's preferred volume. The results of this study showed that radio listening was reinforcing for subjects and the conjugate-reinforcement paradigm was useful for determining reinforcer efficacy. Similarly, Lindsley (1962) evaluated the efficacy of television viewing as a reinforcer using a conjugate-reinforcement schedule. Subjects could press a small switch to increase the brightness of an image on the television. Results showed that television viewing was reinforcing but subjects engaged in less responding to increase the brightness of the television image when commercials were on.

Other studies have shown the utility of the conjugate-reinforcement paradigm for increasing or decreasing socially important target behavior. For example, Green and Hoats (1969) found that a conjugate schedule in which the clarity of the TV picture, volume, and clarity of TV sound maintained as long as the subject was engaged in a target task. For one subject, it was a work task, and for the other it was the absence of gross motor hyperactivity, which included squirming and rocking. Thus, subjects could avoid "TV distortion" by engaging in a certain behavior (or level of behavior for the work task). Results showed that avoiding TV distortion under the conjugate schedule was effective for behavior change. Similarly, Caouette and Reid (1991) increased physical activity by delivering auditory stimulation on a conjugate-reinforcement schedule, and Switzsky and Haywood (1971) demonstrated that gross motor activity could be modified by providing access to motion pictures using a conjugate-reinforcement schedule in 18 institutionalized adults.

A less common schedule of covariation is referred to as a synchronous-reinforcement schedule in which the onset and offset of the reinforcer are perfectly synchronized with the onset and offset of the response (Ramey, Hieger, & Klisz, 1972; Rovee-Collier & Gekoski, 1979; Weisberg & Rovee-Collier, 1998). Thus, the duration of the response directly controls the duration of access to the reinforcing stimulus (Ramey et al., 1972; Weisberg & Rovee-Collier, 1998). The synchronous schedule is similar to the conjugate schedule because in both schedules responding directly controls and covaries with the reinforcer. However, in papers that differentiate between the two schedules, it seems that they are differentiated by how, or the degree to which, the reinforcer covaries with the response (MacAleese, 2008; Rovee-Collier & Gekoski, 1979; Voltaire, Gewitrz, & Pelaez, 2005; Weisberg & Rovee-Collier, 1998). That is, in synchronous reinforcement, the behavior and reinforcer relation is all or nothing—if the behavior is happening, the reinforcer is delivered, whereas, if the behavior is not happening then the reinforcer is not delivered. In contrast, in conjugate reinforcement, some dimension of the behavior controls some dimension of the reinforcer—if the behavior happening at a certain rate or intensity, then the reinforcer is delivered at that rate or intensity.

Similar to the conjugate-reinforcement paradigm, the synchronous-reinforcement paradigm has also been used to study variety of phenomena including (a) various psychological phenomena regarding infants such as infant-sensory feedback control (Smith, Zwerg, & Smith, 1963) and infant motor movement (Siqueland, 1968; Siqueland & Lipsitt, 1966), (b) preference and reinforcing efficacy of social interaction in infants (e.g., Pelaez-Nogueras, Field et al., 1997; Gewirtz et al., 1996), (c) reinforcing efficacy of stimuli in infants (e.g., Friedlander, 1966; Horowitz, 1974a, 1974b; Leuba & Friedlander, 1968), (d) preference and reinforcing efficacy of stimuli for adults with disabilities (e.g., Saunders et al., 2001; Saunders & Saunders, 2011; Saunders et al., 2003), and (e) the effects for increasing target behavior (e.g., Ramey, Hieger, & Klisz, 1972)

Leuba and Friedlander (1968) used a synchronous-reinforcement paradigm to determine play activity of infants by evaluating the effects of audio-visual stimulation on manipulative play activity in the home. If the infants touched one knob, it produced auditory (chimes) and visual (illumination of lights) stimuli; if they touched the other knob, it produced no stimulation. Results showed the infants manipulated the knob that produced the auditory and visual stimuli more than the knob that did not produce stimuli suggesting that the stimuli exercised control over behavior. In another study, Pelaez-Nogueras, Gewirtz, et al. (1996) evaluated infant preference for adult touch (i.e., smiling, vocalizing, and rhythmically rubbing both of the infant's legs and feet with her hands) using synchronous reinforcement. That is, the onset and offset of infant eye-contact responses directly controlled the onset and offset of adult touch. Results showed infants engaged in more eye-contact responses during the touch condition as compared to the no-touch condition suggesting that adult touch was reinforcing and may be used to influence infant behavior. In a follow-up study, Pelaez-Nogueras, Field, et al. (1997) compared two types of touch (i.e., stroking vs. tickling and poking) on infant eye-contact using a synchronous-reinforcement schedule. Results showed that infants spent more time making eye contact during the stroking condition compared to the tickling and poking condition.

Similar to studies with infants, a series of studies by Saunders and colleagues (Saunders et al., 2001; Saunders & Saunders, 2011; Saunders et al., 2003) have used a synchronous-reinforcement schedule for determining preferences and reinforcers with individuals with profound intellectual and developmental disabilities. For example, Saunders and Saunders (2011) evaluated preference for sensory stimulation with participants with profound disabilities by using concurrent synchronous-reinforcement contingencies. Participants used switches to activate and terminate leisure devices (e.g., auditory, tactile, and visual feedback). Results of the study demonstrated that synchronous reinforcement could be used to determine relative preference for potentially reinforcing stimuli. Additionally, these results provide an alternative method to determine preference and reinforcers for individuals who may be difficult to test using other preference assessment procedures.

In addition to studying infant behavior and processes and reinforcer efficacy, we found one study that used a synchronous-reinforcement schedule to increase a socially appropriate behavior. Ramey et al. (1972) used a synchronous-reinforcement schedule to increase vocal output of two failure-to-thrive infants and two maternally-deprived infants. During the conditioning sessions, a visual stimulator displayed brightly colored translucent geometric figures with the onset of each vocal response emitted by the infant. That is, the onset of the reinforcing stimulus was perfectly synchronized with the onset of the response, and the termination of the response resulted in the termination of the reinforcing stimulus. The authors concluded that the duration and frequency of infant vocalizations increased under synchronous reinforcement in the conditioning sessions.

In summary, previous research has used schedules of covariation to study various phenomena; however, few studies have evaluated the utility of these schedules for changing socially important behavior across populations, behaviors, and contexts. Furthermore, few studies, with the exception of a couple basic research studies (e.g., MacAleese et al., 2015; Williams & Johnston, 1992), have studied the schedules in their own right. Thus, little is known about the conditions under which they might be more or less useful and the mechanism by which they result in behavior change. Finally, few studies (e.g., Voltaire, Gewitrz, & Pelaez, 2005) have compared the effects of schedules of covariation with other schedules of reinforcement to compare effects of these schedules to those more commonly used in the literature. Continued research on schedules of covariation is warranted given their ubiquity in our everyday lives (e.g., walking, crawling, singing, playing an instrument, driving, playing sports).

The purpose of the current study was twofold. First, we evaluated the effects of a synchronous-reinforcement schedule for increasing on-task behavior in preschool-age children. To do this, we compared the effects of the synchronous schedule with one in which the duration of access to reinforcers was yoked to the duration of time in which the participant was on-task during the session; however, the reinforcer was delivered continuously for that period of time after the sessions. We referred to this condition as end-of-session reinforcement. Second, we evaluated participant preference for the two schedules of reinforcement.

Method

Participants, Setting, and Materials

Participants were eight typically developing children, ages 2 to 5, who attended a university-based preschool. Based on teacher report and informal observations, all participants were able to (a) follow multi-step instructions (e.g., walk to your cubby, put your backpack away, sit down), (b) remain seated for more than 5 min, and (c) hold a writing utensil to trace shapes. Trained graduate students conducted sessions in session rooms that contained a table, chairs, and relevant session materials. All sessions were conducted in a session block, and each session block consisted of two to three sessions that were conducted consecutively. Sessions were 5 min in duration and session blocks were conducted one to two times per day, 3 to 5 days a week.

During all sessions, target task materials, an alternative task, and a dry erase marker were present (Appendix A). Target task materials included a stack of laminated shape-tracing worksheets (measuring 21.6 cm x 27.9 cm). The worksheets included three rows of shapes (e.g., circles, triangles, and squares) by three columns of shapes for a total of nine shapes on each worksheet (see Appendix B). The alternative task was also present on the table, which was a stack of blank laminated sheets on which the participant could draw. Different colored stimuli were associated with different conditions to aid in discrimination across conditions. That is, we used different worksheet backgrounds, blank laminated sheet backgrounds, and different colored tablecloths on the session table. During reinforcement sessions, the experimenter presented a song board to participants. The song board was a white laminated poster board (measuring 55.8 cm x 71.1 cm) with 10 to 20 laminated picture icons (measuring 4.5 cm x 3 cm) that corresponded with 10 to 20 songs with VELCRO® strips affixed to the back, such that they could be attached to the poster board (see Appendix C). During reinforcement sessions, the experimenter also had an iPod touch™ with a playlist containing the songs depicted on the song board.

Response Measurement, Interobserver Agreement, and Procedural Integrity

Trained observers collected data using handheld data-collection devices. The dependent variable was the duration of on-task behavior (shape tracing), which was scored if the participant was moving the marker steadily and approximately within the boundaries of the thick pre-printed lines on the shape-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 pre-printed 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 shape), or physically manipulating the marker in a manner that prevented tracing (e.g., rolling, tapping, or throwing marker).

A second independent observer collected data for at least 30% of all sessions for each participant across all conditions. Interobserver agreement (IOA) 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. IOA was calculated by dividing the number of seconds in the session with an agreement by the total number of seconds and multiplying by 100. IOA was calculated for 50% of sessions for Martin, and mean agreement for on-task behavior was 93% (range, 82%-100%). IOA was calculated for 57% of sessions for Monty, and mean agreement for on-task behavior was 95% (range, 84%-100%). IOA was calculated for 71% of sessions for Madeline, and mean agreement for on-task behavior was 94% (range, 74%-100%). IOA was calculated for 58% of sessions for Skylar, and mean agreement for on-task behavior was 98% (range, 89%-100%). IOA was calculated for 60% of sessions for Graham, and mean agreement for on-task behavior was 96% (range, 88%-100%). IOA was calculated for 42% of sessions for Konner, and mean agreement for on-task behavior was 93% (range, 84%-100%). IOA was calculated for 54% of sessions for Kyara, and mean agreement for on-task behavior was 97% (range, 90%-100%). IOA was calculated for 61% of sessions for Ella, and mean agreement for on-task behavior was 97% (range, 88%-100%). When IOA for on-task behavior fell below 80% for a given session, the lead experimenter retrained data collectors on the operational definition of on-task behavior to ensure understanding for future sessions and minimize observer drift.

We calculated procedural integrity to determine whether the experimenter correctly implemented the programmed contingencies for at least 30% of all reinforcement sessions (i.e., synchronous and end-of-session reinforcement) for each participant across reinforcer conditions. For both synchronous- and end-of-session 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 end-of-session reinforcement sessions, we calculated procedural integrity 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. Procedural integrity was calculated for 50% of reinforcer sessions for Martin, and mean agreement for reinforcer delivery was 92% (range, 71%-100%). Procedural integrity was calculated for 57% of reinforcer sessions for Monty, and mean agreement for reinforcer delivery was 98% (range, 90%-100%). Procedural integrity was calculated for 71% of reinforcer sessions for Madeline, and mean agreement for reinforcer delivery was 95% (range, 75%-100%). Procedural integrity was calculated for 58% of reinforcer sessions for Skylar, and mean agreement for reinforcer delivery was 96% (range, 67%-100%). Procedural integrity was calculated for 60% of reinforcer sessions for Graham, and mean agreement for reinforcer delivery was 97% (range, 87%-100%). Procedural integrity was calculated for 42% of reinforcer sessions for Konner, and mean agreement for reinforcer delivery was 91% (range, 70%-100%). Procedural integrity was calculated for 54% of reinforcer sessions for Kyara, and mean agreement for reinforcer delivery was 97% (range, 81%-100%). Procedural integrity was calculated for 60% of reinforcer sessions for Ella, and mean agreement for reinforcer delivery was 99% (range, 94%-100%). When procedural integrity for reinforcer delivery fell below 80%, the lead experimenter retrained data collectors on the operational definition of on-task behavior to ensure understanding for future sessions and minimize observer drift. Additionally, the lead experimenter retrained other experimenters on the operational definition of on-task behavior and reinforcer delivery across conditions to ensure understanding of when the reinforcer should and should not be delivered for future sessions. Overall, there were four total sessions, all of which were ESR sessions, where procedural integrity fell below 80%. That is, for Martin, Madeline, Skylar, and Konner, only one session had procedural integrity below 80%.

Determining Preferred Songs

Prior to the study, the experimenter asked (a) four supervisors who work in in the preschool and (b) parents of the first three children who were recruited for our study to list 10 songs that their children (parents) or children in the classroom (teachers) prefer. From those lists, the experimenter determined the 10 most commonly reported songs to include on the song board during reinforcement sessions. However, during the latter part of the reinforcement phase for the first three participants, these participants began reporting that they wanted to listen to other songs than those on the song board. Therefore, for the subsequent five participants, we included the 10 songs that were included for the first three participants, as well as 10 additional songs that were reported via verbal report by individual children or their parents to be preferred. Furthermore, the subsequent five participants could request additional songs not shown on their individualized song board to be used during reinforcement phases.

General Procedures for Reinforcement Schedule Evaluation

During all sessions, the experimenter was seated across the table from the participant and presented a large stack of laminated tracing sheets (target task) and a large stack of laminated blank drawing sheets on the table in front of the participant (approximately 27 cm apart) with a dry-erase marker placed in between them (see Appendix A). The experimenter presented a large stack of both sheets such that the participant would not run out of materials for either task. 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. Prior to all sessions, the experimenter provided a brief rule stating the contingencies associated with the condition and provided exposure to the session contingencies programmed for on-task behavior.

Prior to the reinforcement phase, the experimenter familiarized participants with the songs associated with the different pictures on the song board by conducting three exposure sessions. During these exposure 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. After these three exposure sessions, the reinforcement phase began.

Prior to each reinforcement session, the experimenter displayed the song board and reminded the participant the name of each song while pointing to its corresponding picture. After this, the experimenter asked the participant to pick the songs they wanted to hear the most (typically three songs). Whichever songs the participant picked (by touching the picture or saying the name of the song), those songs were played in the order in which they were selected or requested during reinforcement sessions. During all reinforcement sessions, the experimenter provided attention in the form of conversation while the songs were playing. The experimenter provided attention while the song was playing by 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 are trained to interact with the children, therefore combining the delivery of attention and access to songs more closely resembled how these reinforcers were delivered in the everyday environment.

Baseline. During baseline sessions, discriminative stimuli (e.g., task materials and table cloth) were white. Prior to the session, the experimenter told the participant, "This is the white condition. When you are tracing shapes, nothing will happen. When you draw on the drawing sheets, nothing will happen. You can switch between drawing and tracing and nothing will happen." During pre-session exposure, the experimenter prompted the participant to trace for approximately 10 s and provided no programmed consequences. During the session, the experimenter did not deliver any programmed consequences for engaging in the target task or any other behavior.

Synchronous Reinforcement (SSR). During synchronous-reinforcement sessions, discriminative stimuli (e.g., task materials and table cloth) were blue. Prior to the session, the experimenter told the participant, "This is the blue condition. When you are tracing the shapes, then you will get to listen to (the three chosen songs) and talk with me. When you stop tracing, (the three chosen songs) will turn off and we will stop talking. You can switch between drawing and tracing and when you draw (the three chosen songs) will turn off and we will stop talking and when you trace you will get to listen to (the three chosen songs) and talk with me." During pre-session exposure, the experimenter prompted the participant to trace for approximately 10 s and provided access to a preferred song and attention throughout that 10 s. During the session, the experimenter turned on the preferred songs and provided 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 2 s the experimenter paused the song and stopped providing attention in the form of conversation (e.g., preferred topics or activities) until the participant again began engaging in the task.

End-of-session Reinforcement (ESR). During end-of-session reinforcement sessions, discriminative stimuli (e.g., task materials and table cloth) were red. Prior to the session, the experimenter told the participant, “This is the red condition. For however long you trace shapes, 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. You can switch between drawing and tracing and when you draw you will not get to listen to (the three chosen songs) or talk with me for the entire time after tracing and when you trace you will get to listen to (the three chosen songs) and talk with me at the end of the session.” During pre-session exposure, the experimenter prompted the participant to trace for approximately 10 s and provided access to a preferred song and attention in the form of conversation at the end of the pre-session exposure for the duration of time spent engaging in the task (i.e., 10 s). 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) to measure on-task behavior within the session. The experimenters measured on-task behavior using the same operational definition that data collectors used to collect data. That is, they started the timer when the participant was on-task and paused the timer was not on-task for more than 2 s.

Experimental Design

For all participants, we used a multielement design to compare the effects of the two reinforcement schedule conditions. That is, after we determined baseline levels of on-task behavior for each participant, we rapidly alternated synchronous-reinforcement sessions and end-of-session sessions. The order of conditions was quasi-random such that no more than two of the same conditions were conducted consecutively. For participants who engaged in similar levels of on-task behavior across conditions in the multielement phase of the study, we used a multiple baseline across participants design to show experimental control.

Preference Assessment

Following the comparison of the different schedules of reinforcement, we conducted a preference assessment using a concurrent-chains arrangement (Hanley, Piazza, Fisher, & Maglieri, 2005; Herrnstein, 1964) to determine participant preference for the different conditions. Prior to each session, the participant was presented with all three colored stimuli that were associated with each of the different conditions (baseline, synchronous reinforcement, and end-of-session reinforcement) in a row on the table in front of them (see Appendix D) and reminded of the contingencies associated with each set of materials. For example, the participant was reminded that the white materials meant that there were no songs or attention for tracing, the blue materials meant that they would listen to songs and talk with the experimenter while they were tracing, and red materials meant that they would listen to songs and talk with experimenter after they traced. The placement of the different materials was switched each session (i.e., left, right, and middle). After the experimenter reminded the participant of the contingencies associated with each set of materials, they asked the participant to pick their favorite by pointing to, touching, or naming a set of materials. The experimenter then placed the materials selected on the table and conducted the chosen condition as described above. Trained observers collected data on the condition selected by participants and the duration of on-task behavior.

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

Results

Figures 1-3 depict the duration of on-task behavior for all eight participants. Figure 1 depicts data for Martin (top panel), Monty (middle panel), and Madeline (bottom panel). During baseline, Martin engaged in low levels of on-task behavior. During the reinforcement phase, Martin showed an increase in levels of on-task behavior only in the SSR condition. He engaged in similar levels of on-task behavior in the ESR condition as compared to baseline. During the preference phase, Martin consistently chose the SSR condition and engaged in high levels of on-task behavior during those sessions. During baseline, Monty engaged in low levels of on-task behavior. During the reinforcement phase, Monty engaged in higher levels of on-task behavior during both SSR and ESR conditions as compared to baseline; however, on-task behavior was consistently higher in the SSR condition. During the preference phase, Monty exclusively chose the SSR condition and engaged in high levels of on-task behavior those sessions. During baseline, Madeline displayed a decrease in on-task behavior after the first several sessions.

During the reinforcement phase, Madeline engaged in higher levels of on-task behavior during both SSR and ESR conditions as compared to baseline; however, like Monty, she engaged in slightly higher and more consistent on-task behavior in SSR sessions. During the preference phase, Madeline exclusively chose the SSR condition and engaged in high levels of on-task behavior in those sessions.

Figure 2 depicts data for Skylar (top panel) and Graham (bottom panel). During baseline, Skylar engaged in decreasing levels of on-task behavior. During the reinforcement phase, she showed an increase in levels of on-task behavior only in the SSR condition. She engaged in similar levels of on-task behavior in the ESR condition as compared to baseline. During the preference phase, Skylar exclusively chose the SSR condition and engaged in relatively high levels of on-task behavior during those sessions.

During baseline, Graham engaged in low levels of on-task behavior. Initially during the reinforcement phase, Graham engaged in overall higher but variable levels of on-task behavior in the SSR and ESR conditions as compared to baseline. However, patterns of responding and comments made by Graham suggested he was not discriminating the different conditions. That is, at the start of sessions when the experimenter was stating the rules that corresponded with the different conditions, Graham would often interrupt and say rules that differed from those associated with the contingencies. Therefore, the experimenter conducted several extended training sessions to enhance discrimination across conditions. During these sessions, the experimenter placed both of the color-correlated stimuli associated with the reinforcement conditions next to each other on the table in front of Graham and stated how each of the colors were different and had different rules associated with them. Next, the experimenter modeled tracing on the tracing sheets and drawing on the drawing sheets across both reinforcement conditions and a research assistant provided the consequences associated with each schedule to demonstrate how the contingencies were different across both conditions. Next, the experimenter had Graham state how each of the conditions were different and what would happen if he were to draw on the drawing sheets or trace on the tracing sheets. Finally, the experimenter prompted Graham to trace on the tracing sheets and draw on the drawing sheets for approximately 30 s each and provided the consequences associated with each reinforcement condition. These additional training sessions were 15 min and were conducted across three days after which time Graham accurately stated the contingencies associated with each condition. Following this additional training, the experimenter resumed SSR and ESR sessions, and Graham showed an increased and stable level of on-task behavior only in the SSR condition. He engaged in similar levels of on-task behavior in the ESR condition as compared to baseline. During the preference phase, Graham chose the SSR condition in the majority of sessions and engaged in high levels of on-task behavior in those sessions.

Figure 3 depicts data for Konner (top panel), Kyara (middle panel), and Ella (bottom panel). A multiple baseline across participants design embedded with a multielement design was used to show experimental control with these participants because similar levels of responding occurred at least initially during the reinforcement phase. During baseline, Konner engaged in low levels of on-task behavior. During the reinforcement phase, Konner initially engaged in higher levels of on-task behavior during both the SSR and ESR condition as compared to baseline. However, over time, SSR showed to be more effective for producing maintained high levels of on-task behavior. During the preference phase, Konner chose the SSR condition in the majority of sessions and engaged in high levels of on-task behavior during those sessions.

During baseline, Kyara engaged in low levels of on-task behavior. During the reinforcement phase, Kyara initially engaged in higher levels of on-task behavior during both SSR and ESR conditions as compared to baseline; however, over time, she engaged in slightly higher and more consistent on-task behavior in the SSR condition. During the preference phase, Kyara chose the SSR condition in the majority of sessions and engaged in high levels of on-task behavior during those sessions.

During baseline, Ella engaged in variable levels of on-task behavior. During the reinforcement phase, Ella engaged in more consistently high levels during both SSR and ESR conditions as compared to baseline. During the preference phase, Ella chose all three conditions suggesting that she did not have a clear preference. However, only in sessions in which she chose the SSR or ESR conditions, did she engage in high levels of on-task behavior. Given the purpose of the preference phase was to assess relative preference between the two schedules of reinforcement, the experimenter removed the baseline condition materials and only presented the SSR and ESR condition materials in subsequent sessions. Following this modification, Ella chose both SSR and ESR conditions; however, she engaged in higher and more consistent on-task behavior during SSR sessions.

Discussion

The purpose of the current study was to compare the effects of a synchronous-reinforcement schedule (SSR) with an end-of-session reinforcement schedule (ESR) for increasing on-task behavior in young children. Additionally, we evaluated participant preference for both schedules of reinforcement. Although ESR was effective for increasing on-task behavior over baseline levels for several participants, at least initially, SSR was more effective for increasing on-task behavior for 7 out of 8 participants. For Ella, the results were similar across conditions. Furthermore, all participants but Ella preferred SSR over ESR. For Ella, she selected both SSR and ESR during the preference phase, suggesting no clear preference for one over the other. Overall, these results showed that SSR was more effective and more preferred for increasing on-task behavior in preschoolers.

Although SSR was more effective for most participants, ESR resulted in an increase in on-task behavior over baseline levels for several participants (Monty, Madeline, and Ella). There are several explanations as to why both SSR and ESR were effective, despite the delay of reinforcement in the ESR condition. First, unlike common ratio and interval schedules that might involve engaging in a small amount of work to access a small amount of a reinforcer, both SSR and ESR conditions involved fluent work schedules and a larger amount of uninterrupted reinforcer delivery. In fact, previous research (Fieneup, Ahlers, & Pace, 2011;Ward-Horner, Pittenger, Pace, & Fieneup, 2014) has suggested that fluent work schedules in which work is uninterrupted and in which a longer duration of uninterrupted access to the reinforcer may be more effective and preferred over less fluent work schedules and shorter duration of reinforcers. Additionally, several studies have suggested that longer duration of access to reinforcers may increase the preference and value of those reinforcers (e.g., DeLeon et al., 2014; Steinhilber & Johnson, 2007). In fact, DeLeon et al (2014) suggested that reinforcing value and effectiveness of certain stimuli as reinforcers (i.e., activities that have a beginning, middle, and end such as games, videos, puzzles) may depend on the continuity of access and progression through each stage of the activity. Similarly, in our study, access to music and conversation may be affected in the same manner. That is, the value of these stimuli may be increased if the participant is able to listen to the entire song, favorite part of the song, get through an entire conversation, or talk about several preferred topics. In the future, researchers could evaluate whether continuity of access influences the reinforcing efficacy and preference for certain activities as compared to others.

For most participants (7 out of 8), SSR was more effective and preferred than ESR for increasing on-task behavior even though the duration of reinforcement was yoked to response duration in both schedules. There are several possible reasons for these results. First, access to reinforcement was immediate in the SSR condition and delayed in the ESR condition (i.e., after the session ended). Therefore, patterns of responding observed under SSR and ESR schedules may be similar to those observed under other immediate and delayed schedule arrangements (Lattal, 2010). Second, it is possible that moment-to-moment changes in reinforcer access during the SSR condition influenced responding. That is, with the SSR schedule, the duration of participant on-task behavior was perfectly synchronized with the duration of access to the reinforcer, which may have provided a more sensitive reinforcement contingency for behavior change. Third, it is possible that the removal of music and conversation during the SSR condition functioned as negative punishment resulting in more effective behavior change. That is, during the SSR condition, if the participant was not on task (i.e., not tracing or tracing incorrectly) for more than 2 s, then the experimenter paused the song and stopped providing attention until the participant again was on-task. Fourth, it is possible that the work task (tracing) was less aversive during the SSR condition because of the ongoing availability of reinforcers during the work task. In fact, previous research suggests access to preferred items and activities during work tasks may make the task less aversive and more preferred (Carr, Newson, & Binkoff, 1980; Lalli et al., 1999; Lomas, Fisher, & Kelley, 2010; Wallace, Iwata, Hanley, Thompson, & Roscoe, 2012).

Although results of the current study suggest that SSR was more effective and more preferred for increasing on-task behavior in preschoolers for most participants, there are several limitations. One limitation is that the SSR schedule may not be amenable to all behaviors. That is, the delivery of reinforcement while behavior is occurring may interfere with some behaviors. For example, if the target behavior is reading comprehension or a more complex academic behavior, the delivery of reinforcers such as music or conversation may be disruptive and interfere with the occurrence of the target response. Additionally, this reinforcement procedure may be disruptive to other peers in close proximity. For example, during naptime, a teacher could reinforce appropriate on-cot behavior (i.e., remaining seated on cot, keeping hands and feet to self, and using a quiet voice) by providing physical attention (e.g., back rubs). However, if the teacher provided other topographies of attention (e.g., praise or conversation), they may be disruptive to other children who are trying to fall asleep.

Another limitation is that it may not be possible to deliver reinforcers using an SSR schedule. That is, some reinforcers might involve more discrete deliveries (e.g., small edible, sticker) that are not amenable to this type of schedule of reinforcement. Additionally, it may not be feasible for teachers, caregivers, or staff to continuously observe the responding of an individual and synchronize the delivery of access to reinforcers with the target behavior. To address this limitation, researchers may consider automating the delivery and removal of reinforcing stimuli using procedures similar to those described by Lindsley (1962). Researchers could also automate reinforcement delivery with technology and video games (e.g., Kinect, TV; Biddiss & Irwin, 2010; Faith et al., 2001)

There are several methodological limitations worth mentioning. First, multiple rules were provided to participants to aid in discrimination between conditions and it is unknown to what extent the rules played in differential responding. As mentioned, one of our participants, Graham, created self-generated rules that influenced his responding, which was only corrected after providing him with additional exposure to the rules and contingencies. Future research should determine the influence of these schedules with individuals who have less receptive skills to determine whether similar results would be obtained. Second, although SSR and ESR sessions were both 5 min, the duration of time participants were in the session room was different across conditions. That is, during all SSR sessions, participants left the session room after sessions because access to reinforcement was delivered within session. However, during ESR sessions, reinforcer access to was provided after session and the duration was based on the duration of on-task behavior during session. Therefore, they did not leave the session room until after their 5 min session plus reinforcer access time. Therefore, from a molar perspective, the longer “session” duration in ESR may have influenced responding.

There are various avenues for future research on schedules of covariation including combined schedules (e.g., combining conjugate and synchronous schedules). Researchers could replicate and extend the current study to other populations and behaviors. For example, researchers could evaluate the influence of SSR with school-age children, adults, and elderly individuals. Additionally, researchers could evaluate the influence of SSR on various behaviors such as problem behavior, transition behaviors, hygiene and self-help skills (e.g., toothbrushing, handwashing), physical activity, and pre-academic skills. Additionally, researchers should evaluate the degree to which behavior maintains under SSR.

Another avenue for future research is to determine the influence of SSR on group behavior. For example, researchers could evaluate the utility of SSR as a classroom management procedure to increase on-task behavior of a group of individuals. That is, experimenters could deliver access to preferred conversation and songs to reinforce the on-task behavior of a group of individuals, appropriate mealtime behavior in schools, appropriate naptime behavior in preschools, clean up in preschool and elementary schools, and physical activity.

Researchers might also consider extending this line of work by comparing schedules of covariation with other common schedules (ratio and interval schedules) to determine their efficacy and conditions under which they are most likely to be effective. Comparing these different schedules might allow us to determine the influence of duration of reinforcement, uninterrupted and continuous access to reinforcers, covariation in response and reinforcer, uninterrupted and continuous work, and combinations of factors on the efficacy and preference for these schedules. Furthermore, it would be interesting to compare the effects of SSR and CSR schedules to determine the mechanisms responsible for behavior change. That is, researchers could isolate relevant variables such as reinforcer delivery that may be responsible for behavior change. For example, it is unknown whether CSR is effective due to the moment-to-moment changes in the reinforcer delivery and covariation of some dimension of behavior *and* the change in some relevant dimension of reinforcement. Thus, a comparison of these schedules may allow us to rule this out.

As mentioned, schedules of covariation including conjugate and synchronous schedules are common in the everyday environment (Lindsley, 1962; MacAleese, 2008; Rovee-Collier & Gekoski, 1979; Voltaire, Gewirtz, & Pelaez, 2005). For example, when an infant cries, the frequency, duration, and intensity of crying may prompt a caregiver to respond more rapidly. In another example, individuals often engage in physical activity and listen to music or watch a preferred movie simultaneously. Thus, the onset of physical activity on a workout machine at the gym is synchronized with the onset of access to music and movies; access to these reinforcing stimuli terminates when the individual stops engaging in physical activity on the workout machine. Other examples of conjugate and synchronous schedules in the everyday environment include stereotypic behavior, walking, running, crawling, driving, singing and talking, and playing instruments. Given the ubiquity of these two schedules in the everyday environment, more research is warranted to gain a better understanding of these schedules and how they influence behavior.

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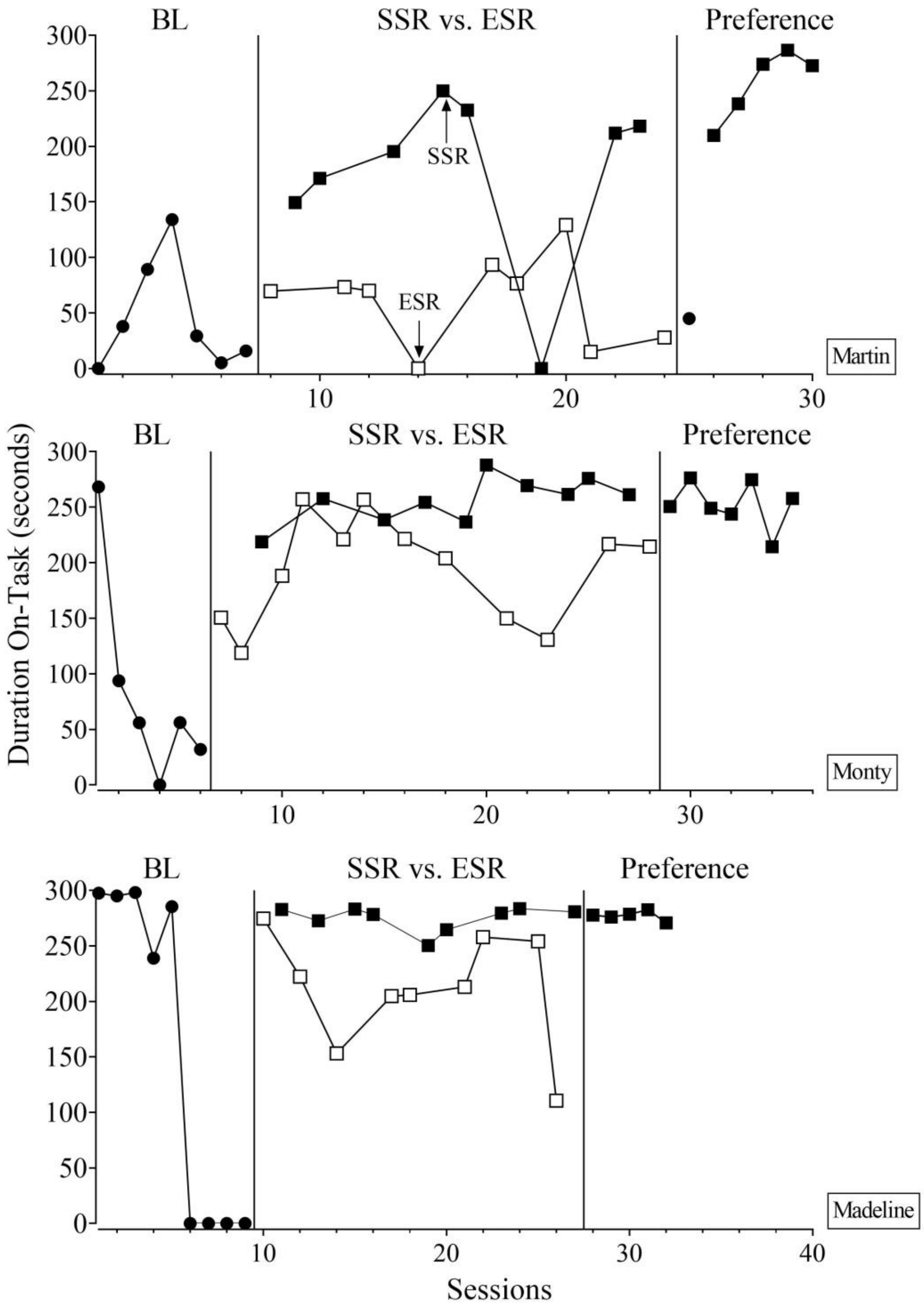


Figures

Figure 1. This figure depicts the data for Martin (top panel), Monty (middle panel), and Madeline (bottom panel). These data are depicted as duration of on-task behavior in seconds. The closed circles depict baseline sessions, the closed squares denote SSR sessions, and the open squares denote ESR sessions.

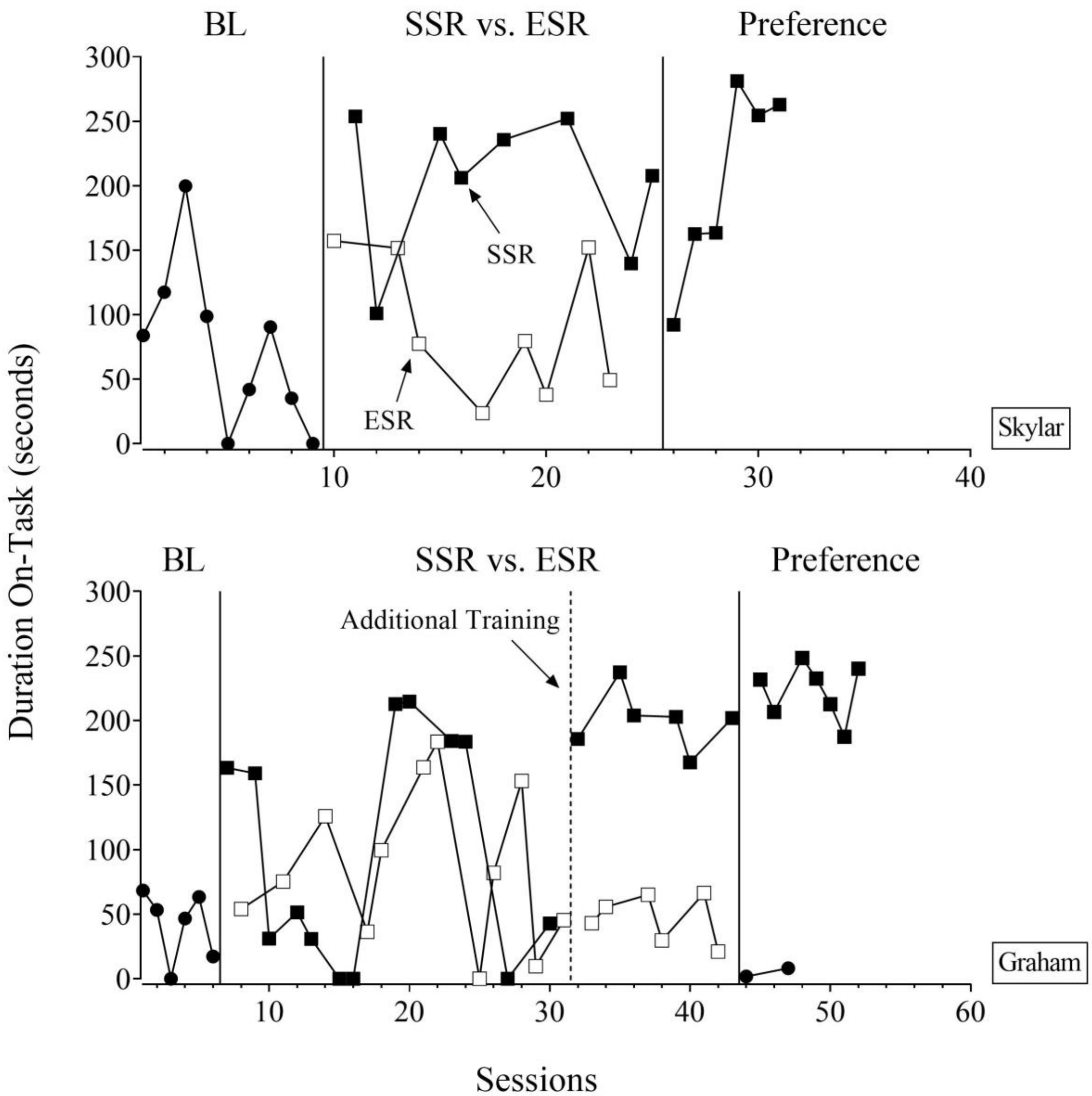


Figure 2. This figure depicts the data for Skylar (top panel) and Graham (bottom panel). These data are depicted as duration of on-task behavior in seconds. The closed circles depict baseline sessions, the closed squares denote SSR sessions, and the open squares denote ESR sessions. The dotted phase line (bottom panel) denotes additional training sessions that were conducted with Graham to enhance discrimination across conditions.

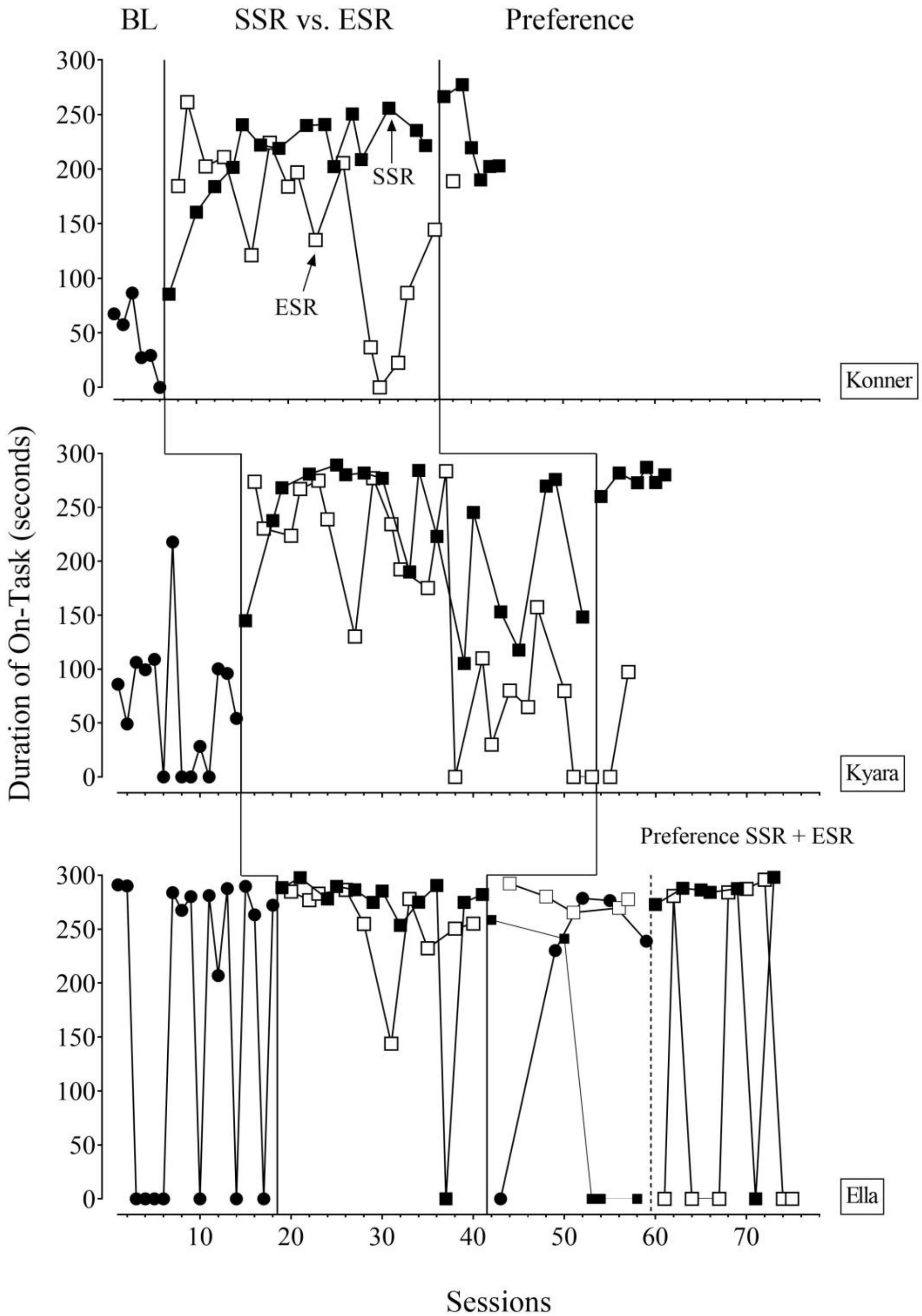
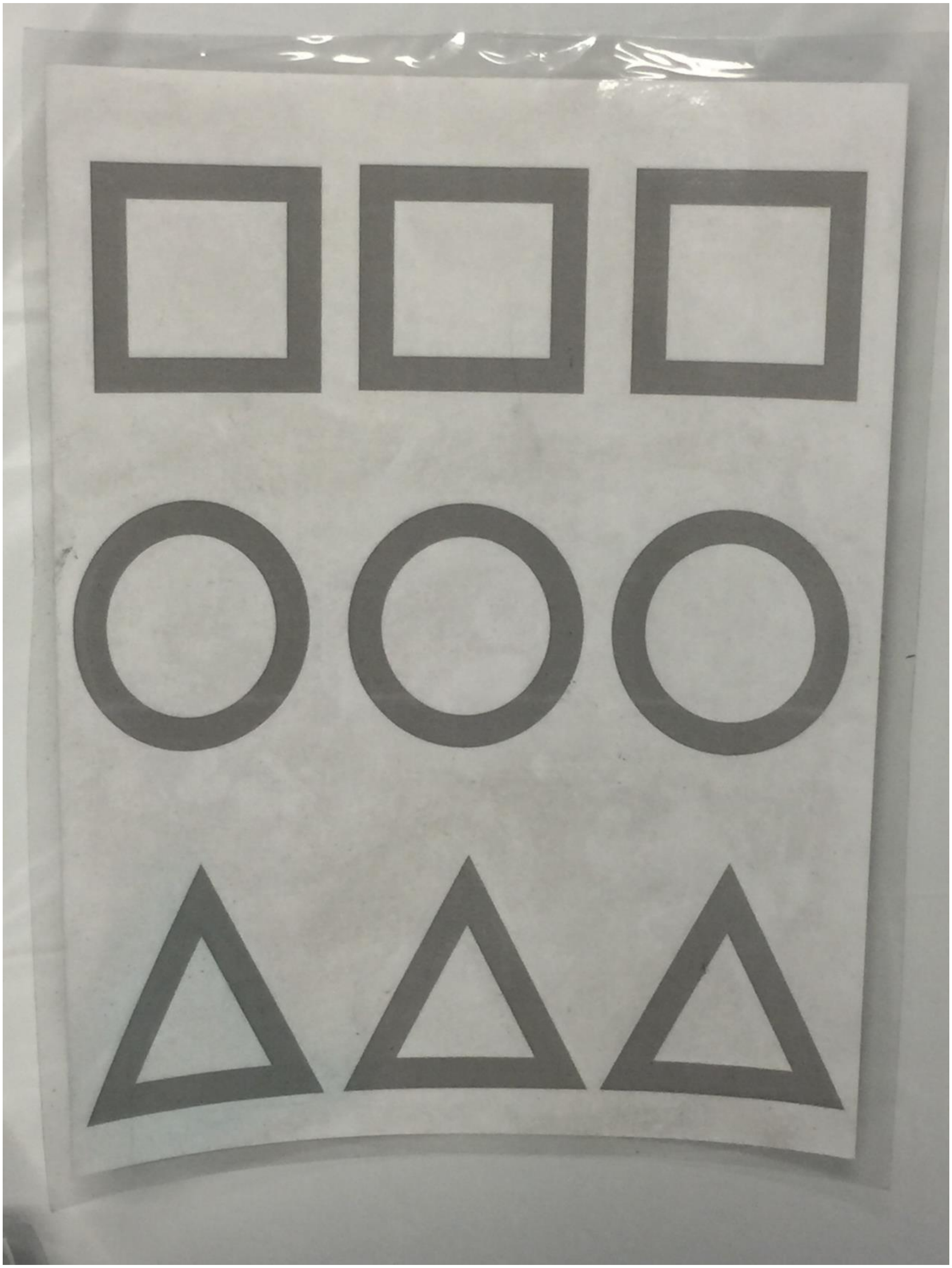


Figure 3. This figure depicts the data for Konner (top panel), Kyara (middle panel), and Ella (bottom panel). These data are depicted as duration of on-task behavior in seconds. The closed circles depict baseline sessions, the closed squares denote SSR sessions, and the open squares denote ESR sessions. The dotted phase line (bottom panel) denotes a modification in the preference condition that was conducted with Ella.

Appendix A

Appendix B



Appendix C


UPTOWN FUNK
GET LOOSE
we dont talk anymore
Im the One
THE MIDDLE

Appendix D