Continuous and Brief Conditioned Reinforcers: A Comparative Analysis

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Abstract

Brief and continuous conditioned reinforcers have been shown to have differential effects under some circumstances. A reinforcement effect has been demonstrated when brief conditioned reinforcers are delivered contingent on responding under second-order schedules of reinforcement. Alternatively, continuously present conditioned reinforcers that are associated with the initial components of fixed-ratio (FR) second-order token or extended-chained schedules of reinforcement have been shown to result in response suppression under high ratio requirements. Although both of these types of reinforcers are used extensively in applied settings, there has been limited research on the differential effects these stimuli may have on the behavior of humans in clinical and educational applications. The purpose of the present study was to assess the relative effects these types of conditioned reinforcers have in sustaining responding in humans under progressive-ratio schedules, concurrent schedules, and in the absence of primary reinforcement. Our results showed progressive-ratio (PR) schedules of continuously present conditioned reinforcement maintained higher response counts relative to those obtained under brief conditioned reinforcement and tandem schedules in three of four participants. The results of the concurrent-chained analysis showed preference for brief conditioned reinforcement for two participants, continuously present conditioned reinforcement for one participant, and indifference for the remaining participant. In the absence of primary reinforcement, results showed that the continuously present and brief conditioned reinforcers maintained reinforcing efficacy longer for two and one participant, respectively, whereas both conditioned reinforcer types maintained reinforcing efficacy for the remaining participant.

Keywords: conditioned reinforcement, progressive-ratio schedules, second-order schedules, extended-chained schedules, token reinforcement, brief stimulus, concurrent-chains

Continuous and Brief Conditioned Reinforcers: A Comparative Analysis

Conditioned reinforcement is a particularly important concept in the field of behavior analysis. It has proven to be robust in the scientific interpretation of complex human behavior and is the primary mechanism underlying the effectiveness of one of the most commonly used behavioral technologies, token economies (Donahoe & Palmer, 2004; Hackenberg, 2009). As such, research on the effects different types of conditioned reinforcers have on responding as well as the variables that may modulate the conditioned reinforcing stimulus function should be of interest to both practitioners and the field at large. The basic research literature provides multiple examples on how arrangements of differing conditioned reinforcers types across schedule types and parameters values affect responding (Foster et al. 2001; Jwaideh, 1973; Malagodi et al. 1973). That said, there is a paucity of clinically-oriented research on the differential effects conditioned reinforcer types may have on responding as well as how conditioned reinforcement schedules and parameter values modulate the stimulus functions exerted. This is due, in part, because the applied and basic lines of research on in this area have advanced largely independent of one another over the last five decades (Hackenberg, 2018). The applied research has focused primarily on practical considerations of development of token economies and areas such as staff training, generalization, maintenance, and treatment integrity while basic research has focused more on the underlying behavioral mechanisms (Hackenberg, 2018; Kazdin, 1982). This divergence between the applied and basic research has produced gaps in the literature which, in turn, has resulted in a general lack of understanding of the critical variables that should be considered when arranging conditioned reinforcers.

A common arrangement for studying conditioned reinforcement is through the use of second-order schedules of reinforcement (Hackenberg, 2009). For example, second-order token

schedules of reinforcement consist of three primary components: (a) the token-production schedule which specifies the number of responses required for each token, or conditioned reinforcer, delivery, (b) the exchange-production schedule which specifies the number of tokens that must be accumulated for exchange, and (c) the token-exchange schedule which specifies the token to primary reinforcer exchange ratio (Malagodi, 1967). Extended-chained schedules of reinforcement are another means of arranging conditioned reinforcers and operate similar to second-order token schedules of reinforcement in that there is a distinct stimulus change across at least three component schedules until the completion of the terminal component schedule and the delivery primary reinforcement (Kelleher & Gollub, 1962). The primary differences between extended-chained schedules and token schedules are that the former do not include a token-exchange schedule nor require an exchange response to access primary reinforcement. Second-order brief-stimulus schedules are another type of conditioned reinforcer arrangement. In these schedules brief conditioned reinforcers are presented for short intervals contingent on responding. Examples include praise statements, a 1- to 2-s illumination of a light, or the presentation of a tone contingent on responding (Finley and Brady, 1965; Malagodi et al., 1973). Thus, on a second-order brief-stimulus schedule, responding is reinforced through the delivery of a brief stimulus according to some production schedule (i.e, first order schedule) and primary reinforcement is delivered after a specified number of component schedule completions (i.e., second-order schedule).

There are multiple examples of these conditioned reinforcers types and arrangements producing response patterns during components of second-order schedules that are characteristic of simple schedule performance (e.g., FI scalloping, FR “break and run”, etc.), which serves as evidence that they can exert a reinforcing function similar to primary reinforcement under certain

conditions (Kelleher, 1958; Malagodi, 1967; Reed, 1994). That said, basic researchers have also shown that these stimulus functions may be more complex and can change as a function of variables such as schedule type, production schedule value, exchange-production schedule value, exchange schedule value, delay to exchange, and type of conditioned reinforcer (Bullock & Hackenberg, 2006; Bullock & Hackenberg, 2015; Foster et al., 2001; Leon et al., 2016; Malagodi et al., 1973). For example, in addition to a reinforcing function, stimuli embedded within second-order token and extended-chained schedules have been shown to also elicit responding or exert discriminative functions resulting in differential effects on responding under these schedules relative to control comparisons (Bullock & Hackenberg, 2015; Foster et al., 2001; Jwaideh, 1973). Specifically, basic research has demonstrated second-order token and extended-chained schedules may result in increases in pre-ratio pausing and decreases in response rates particularly during early components (Bullock & Hackenberg, 2006; Bullock & Hackenberg, 2015; Foster et al., 2001; Jwaideh, 1973).

Decreased response rates and increased PRPs under relatively larger exchange-production values were demonstrated by Foster et al. (2001). These authors compared responding under variable-ratio (VR) and FR exchange-production schedules of reinforcement. Pigeons' key pecks produced tokens which then were exchanged for grain upon completion of the schedule. Tokens consisted of 30 evenly spaced red light-emitting diodes (LEDs) positioned on the intelligence panel above the response key. The token-production schedule remained constant at FR 50 while the exchange-production values were systematically titrated from FR 1 to FR 8. Results showed longer preratio pausing (PRP) and greater suppression of responding in the initial components of the second-order token schedule as the FR exchange-production parameter value increased. This effect was less evident in the response patterns produced under

the VR exchange-production schedule with response rates remaining more consistent and differentially shorter pausing evident in the initial components as the exchange-production schedule values increased. These results show the differential effects on responding which may occur under FR second-order token schedules, at the relatively higher parameter values.

Experiment 2 of Bullock and Hackenberg (2015) demonstrated that the early components of FR extended-chained schedules of reinforcement result in a more prominent suppressive effect relative to token schedules. Response patterns of four pigeons under standard chained, reverse chained, and variable chained schedule arrangements were compared to those produced under a second-order token schedule. An FR 4 (FR 50) second-order schedule was used across the standard chained and token schedule conditions. The standard chained schedule operated identical to the second-order token schedule, using the same schedule values and stimuli associated with each component of as the token schedule, with the exception that a single primary reinforcement interval was delivered following completion of all component schedules relative to 1.5 s access to grain for each token exchanged at the completion of the token schedule. The reverse chained schedule operated identically to the standard chained schedule with exception that the schedule started with four tokens present and one was removed every 50 responses. In the variable chained schedule, a VR 50 token production schedule was implemented and the exchange production schedule varied up to a maximum of 12 tokens with the exchange schedule remaining fixed at 200 responses. As such, it was possible to enter the exchange period with more or less than four tokens under the variable chained schedule. Results from experiment 2 showed lower response rates in the standard chained schedule compared to the second-order token schedule. In addition, lower response rates were obtained under the second-order token schedule, for three of four pigeons, relative to the reversed and variable

chained schedules. Although overall response rate patterns were generally the same across schedules, the standard chained schedule produced lower response rates in the first two components of the schedule relative to the other schedules evaluated. These response patterns provide evidence that the suppressive effect observed in early components of both chained and second-order schedule token schedules are similar but more pronounced under extended-chained arrangements. This replicates previous research on response patterns under chained schedules of reinforcement which show similar effects at relatively high second-order parameter values (Jwaideh, 1973; Kelleher, 1966; Kelleher & Gollub, 1962).

Glodowski et al. (2020) provided the only demonstration of second-order token schedules producing differential effects on responding with humans. These researchers attempted to conduct a systematic replication of Bullock and Hackenberg (2015) with four adolescent males who were diagnosed with autism spectrum disorder. The effects of increases to the exchange-production schedule value, token production value, or both on rate of a target touching response and PRPs were evaluated. Results showed that the token schedule produced lower response rates relative to the yoked tandem schedule across all exchange-production parameter values for one participant and at relatively larger token-production values for another. No differences in response rate were obtained across token and tandem schedules for the other two participants included in the study. One participant's results showed consistent differences in PRPs across token and tandem schedule with the token schedule producing longer PRPs across initial and terminal components relative to the tandem schedule. Whereas the effects of exchange-production and token-production schedule value manipulation were inconsistent across participants, the response suppression produced under a clinically common token schedule for one participant and at a relative high schedule value for a second participant, is the first

demonstration of this effect in humans. Given the inconsistency of the findings across participants and schedule parameters, additional research focusing on the identification of the boundaries of generality of this effect is warranted.

The results of these studies demonstrate the potential deleterious effects on responding FR second-order token and extended-chained schedules of reinforcement may produce under relatively large schedule values (Bullock & Hackenberg, 2015; Foster et al., 2001; Jwaideh, 1973). In fact, it is likely that the continuous nature of the component stimuli in these arrangements is a critical variable in the suppressive effect observed. The lack on contiguity between the early components of the schedule and primary reinforcement when the value of the exchange-production schedule is relatively large results in the stimuli associated with early components signaling extinction instead of functioning as conditioned reinforcers (Bullock & Hackenberg, 2015; Foster et al., 2001 Jwaideh, 1973). This may give practitioners pause when designing token schedules for their clients as this effect is contrary to the conditioned reinforcing function that is assumed to be operating in the majority of clinical or educational contexts.

Conversely, embedding brief stimuli into second-order schedules of reinforcement may have a facilitative effect on responding as Findley and Brady (1965) demonstrated. In their study a brief conditioned reinforcer was delivered throughout a relatively large FR schedule of reinforcement, resulting in improved maintenance of responding and increased response rates. The experimental procedure consisted of a multiple schedule of reinforcement that was composed of a brief second-order FR 10 (FR 400) schedule and a simple FR 4000 schedule. The target response was a button press, and 0.5 s hopper light illumination served as the brief stimulus that was presented contingent on every 400 responses throughout the brief second-order schedule of reinforcement. Primary reinforcement, in the form of a food pellet, was delivered

across both multiple schedule components following 4000 total responses. Results showed that the brief second-order schedule of reinforcement produced smaller PRPs and more sustained periods of relatively higher response rates compared to the response patterns produced under the simple FR schedule.

Malagodi et al. (1973) also demonstrated the facilitative effect the addition brief conditioned reinforcers may have on responding compared to multiple different types of second-order schedules for which they were not embedded. These researchers compared the response patterns produced under seven second-order FR 2 (FI 2-min) schedule arrangements with three pigeons. The rate of key pecking across first-order components served as the primary dependent variable. The seven second-order FR 2 (FI 2-min) schedules implemented were: (1) standard tandem, (2) food-paired brief stimulus, (3) non-paired brief stimulus, (4) standard chained, (5) chained with food-paired brief stimulus, (6) chained with non-paired brief stimulus, and (7) standard multiple.

Results showed increases in response rates across the first component of the FR 2 (FI 2 min) schedule under three conditions: (1) the chained with food-paired brief stimulus second-order schedule, (2) the food-paired brief stimulus second-order schedule, and (3) the standard multiple schedule. In contrast, the standard chained, chained with non-paired food, standard tandem, and non-paired brief stimulus second-order schedules produced relatively lower or inconsistent response rates in the first component. These results demonstrate that the brief stimuli paired with food (i.e., brief conditioned reinforcers) consistently increased responding across the first schedule component, similar to the response pattern produced when primary reinforcement was delivered following the first component of the multiple schedule.

These lines are research across continuously present and brief conditioned reinforcers highlight areas that are ripe for additional examination with clinical populations. Translational research is uniquely suited to bridge the gap between basic and applied research. These types of experiments are specifically designed such that the basic process identified in the tightly controlled experiments of basic research may be used to help refine and develop behavioral technologies used in practice (Lerman, 2003; Mace & Critchfield, 2010). The initial step in a new line of translational research typically consists of the systematic replication or extension of the findings of basic research with clinical populations (Lerman, 2003). Subsequently, additional research further analyzing the critical variables effecting the identified functional relations and their boundaries of generality is conducted (Lerman, 2003). There are numerous examples of the translational research approach successfully bridging basic findings and clinical research resulting in the refinement of behavioral technology and advancement of clinical practice (see Lerman, 2003 for a detailed review of these studies). As such, the application of the translational research approach to the aforementioned lines of research on token continuously present and brief conditioned reinforcers should allow for the continued refinement of conditioned reinforcement technologies, such as token schedules of reinforcement, used by practitioners.

Taken together, the results of these studies demonstrate differential effects of conditioned reinforcers under extended-chained, token, or brief second-order schedule arrangements. These results in and of themselves should be of interest to applied researchers as there have been virtually no comparative analyses on the effects these two types of conditioned reinforcers may have on human behavior under schedule parameters commonly used in practice. This may, in turn, allow behavior analysts to further refine or develop current scientific interpretations of complex human behavior. At the very least, human operant research informed by the results of

the basic literature on the effects of continuously present and brief conditioned reinforcers represents a step in towards bridging the gap that has formed between basic and applied research on token reinforcement (Hackenberg, 2018).

To that end, this study consists of two translational experiments. In experiment 1, we used a PR schedule to compare responding under extended-chained and brief-second-order schedules of reinforcement. The use of a PR schedule allowed us to efficiently compare the effect of schedule values ranging from clinically relevant to those more common in basic research. The use of extended-chained, relative to second-order token, schedules provide both experimental and interpretive benefits when making direct comparisons across conditioned reinforcer types. Specifically, extended-chained schedules have shown to have a greater suppressive effect in early component schedules relative to second-order tokens (Bullock & Hackenberg, 2015). Further, extended-chained schedules provide a cleaner comparison relative to second-order brief schedules as neither includes token-exchange schedules nor requires an exchange response. Experiment 2 consisted of two additional comparative analyses examining measures of these conditioned reinforcer arrangements that may have implications on clinical practice. First, participant preference of the brief and extended-chained was obtained through choice responding during a concurrent-chained analysis. This was followed by an examination of which conditioned reinforcer type was relatively more durable by removing primary reinforcement and measuring the maintenance of responding by each conditioned reinforcer. As a whole, these analyses were designed to provide a comprehensive comparison of two these conditioned reinforcer arrangements and types.

General Method

Participants and Setting

Dillon, Aaron, Carl, and Kyle participated in all experiments of the study. Dillon was a 20-year-old male diagnosed with autism spectrum disorder. He communicated using an AAC device and 2- to 3-modified signs. Aaron was an 18-year-old male diagnosed with autism spectrum disorder. He was vocal-verbal and communicated in full sentences. Carl was a 19-year-old male diagnosed with autism spectrum disorder. He communicated using sign language, a communication book, and vocal verbal approximations. Kyle was a 17-year-old male diagnosed with autism spectrum disorder. He was vocal-verbal and communicated using three- to five-word utterances. All participants attended a residential school for children with developmental disabilities. Sessions were conducted in a research room at the school, in the participant's typical classroom, or in a separate space in the residential home the participant resided in. All locations were kept quiet with limited distractions.

Materials and Target Response

Paperclipping index cards and placing them in a bin served as the primary response across experiments comprising the present study. Paperclipping was defined as picking up one or more index cards from each of the two piles placed directly in front of the participant, paperclipping them together, and placing the paperclipped cards in an adjacent plastic bin. The two stacks of index cards and paperclips used to emit the response were placed on a laminated piece of blue, orange, or pink construction paper across the brief praise, extended-chained, and tandem conditions, respectively.

For the Dillon and Carl, a target touching response replaced the paperclipping response. This shift in target response occurred for Dillon as it was discovered that he engaged in

automatically maintained manipulation of the paper clips used for the paperclipping response resulting in a disruption to free operant responding. The target touching response was used for Carl as he demonstrated difficulty with the fine motor hand control required to efficiently paperclip the index cards together and began bending the paperclips while emitting the response. The target touching apparatus used consisted of a piece of poster board 68 cm x 18 cm in size. The two targets used consisted of laminated sheets of paper, the color of which changed according to condition, measuring 9 cm x 12 cm were affixed to the apparatus with Velcro® approximately 51 cm apart. Target touching was defined as the participant's hand contacting one of the targets then lifting that hand and contacting the other target without making contact with any other stimulus during the transfer. For Dillon, the stimuli that served as touching targets were colored blue, orange, or pink to correspond with the brief, continuous, and tandem conditions, respectively. Participants were taught these responses using a progressive 2-s delay prompting hierarchy prior to starting the schedule thinning phase of the study (O'Neill, McDowell, and Leslie, 2022). The primary reinforcer identified by the paired stimulus preference assessment (PSPA) was also used during these training sessions to reinforce prompted or independent paperclipping or target touch responses.

The stimulus board used during the extended-chained schedules, implemented across all experiments, consisted of laminated white piece(s) of paper which displayed a grid corresponding to the second-order schedule being implemented. For example, during the schedule thinning phase, this board was composed of several equal sized boxes which corresponded to the current second-order thinning step (i.e., two equal sized boxes were displayed on the board during the FR 2 (FR 2) thinning step, six boxes during the FR 6 (FR 2) step, etc.). For the remainder of the manuscript, we will use the term "continuously present

stimulus" (CPS) to describe stimuli associated with the components of the extended-chained schedule. The CPS used for all participants was an "X" drawn by the experimenter contingent on the completion of each first-order schedule of the extended-chained using black Expo® marker. These were drawn into each box of the grid in sequential order starting at the top left. Subsequent stimuli were drawn in the box immediately to the right of the previous "X" as the first-order schedule requirement was met during the session. During brief praise sessions, the statement "Amazing Job!" was delivered contingent on completion of each first order schedule for Kyle, Carl, and Dillon whereas "Amazing!" was delivered following first order schedule completions for Aaron.

Experiment 1

Prior to implementation of the PR analysis, a paired stimulus preference assessment (PSPA) and a second-order schedule thinning procedure was completed for all participants. The results of the PSPA were used to identify a highly preferred primary reinforcer for use during subsequent experiments of the present study. The schedule-thinning phase of the study served a dual purpose. First, the initial schedule values implemented in the thinning process, FR 1 (FR 2), resulted in the repeated response-contingent pairing of the stimuli being used as conditioned reinforcers. This pairing of a stimulus with a primary reinforcer contingent on a response is a procedure that has been demonstrated to establish reinforcing stimulus functions in neutral stimuli in both applied and basic research (Dozier et al., 2012; Kelleher & Gollub, 1962). The second purpose of the schedule thinning phase of the study was to establish identical proximal histories for both stimulus types, brief and continuous, within the experimental context.

The first experiment of the study-proper was the PR analysis. This served two purposes. First, this analysis was designed to determine whether the brief or extended-chained schedules of

reinforcement maintained differential amounts of responding when arranged across separate PR schedules. Second, a PR schedule composed of second-order tandem schedules, which had identical schedule values to the brief and continuous PR schedules, was included in order to determine the amount of responding that would be maintained under this arrangement with solely primary reinforcement. This allowed a comparison of the amount of responding maintained under the tandem PR schedule to that maintained under the brief and continuous PR schedules. If the brief and continuous PR schedules reliably maintained more responding relative to the tandem PR schedule, evidence was provided that the brief and token stimuli were functioning as conditioned reinforcers. Significant overlap between responding maintained under the brief or continuous PR schedules and the tandem PR schedule would indicate that the stimuli included in the brief or continuous PR schedule were not exerting a stimulus function. If this result was obtained, a remediational conditioned reinforcement establishment procedure designed to establish a stimulus function in the neutral brief or continuous stimulus was implemented. The details of these procedures are described in the Discrimination Training procedure section below.

Method

Response Measurement and Dependent Variables

PSPA. The primary dependent variable (DV) of the PSPA was the percentage of trials each stimulus was selected. This percentage was calculated by dividing the total trials each stimulus was selected by the total number of trials in which the stimulus was presented. This yielded the percentage of trials selected for each stimulus included in the assessment.

Schedule Thinning. The primary dependent variable of the schedule thinning phase was responses per minute. The duration the response materials were available and the total number of

responses emitted per session (i.e., response count) were measured. Responses per minute was calculated by taking the quotient of total of responses emitted in the session and the total duration the response materials were available.

PR analysis. The primary DVs of the PR analysis were response count (i.e., the total number of target responses emitted during one PR session) and the 1-min breakpoint criterion which operated across the PR analysis. Target responses for each participant were identical to those described in the "General Method" procedure section above.

Discrimination training. The occurrence of an actual or attempted consumption response across S^D and S^Δ intervals served as the target response. A consumption response was defined as the participant's hand attempting to or contacting a primary reinforcer from the pool of primary reinforcers placed on a table equidistant between the therapist and participant. The DVs measured during each session of the discrimination training procedure consisted of number of S^D intervals with a consumption response, the number of S^Δ intervals with a consumption response, prompted responses during S^D intervals, and independent responses during S^D intervals. These measures were then converted into proportions of S^D and S^Δ intervals per session which were the primary DVs of this procedure.

Interobserver Agreement

Preference assessment. IOA was calculated by having a second independent observer score participant selections for 100% of preference assessment trials. The total number of trials in agreement were divided by the total number of trials with agreement and disagreement multiplied by 100 yielding a percent agreement measure. Across all participants, 100% agreement was obtained selections of the PSPA.

Second-order schedule thinning. For each participant, IOA for extended-chained and brief sessions comprising second-order schedule thinning was obtained by having a second independent observer score session videos using the data collection software. Proportional IOA was calculated for the occurrence of target responses. To calculate IOA, each session was divided into 10-s intervals. For each 10-s interval comprising the session, the smaller number of target responses was divided by the larger number scored. These intervals were then averaged together and multiplied by 100 yielding a proportional percent agreement measure. For Dillon 34% of sessions were scored, IOA was 98% (range 80% - 100%) and 95% (range 80%- 100%) for the target response and duration the response materials were available, respectively. For Aaron 33% of sessions were scored, IOA was 98% (range 84% - 100) and 96% (range 88% - 100%) for target responses and duration the response materials were available, respectively. For Kyle 33% of sessions were scored, IOA was 96% (range 83% - 100) and 97% (range 84% -100%) for the occurrence of the target response and duration the response materials were available, respectively. For Carl 32% of sessions were scored, IOA was 95% (range 81% - 100) and 96% (range 86% - 100%) for the target response and duration the response materials were available, respectively.

PR analysis. For each participant, IOA was calculated across continuous, brief praise, and tandem sessions of the PR analysis as described in the "second-order schedule thinning" section above. For Dillon, 43% of sessions were scored for IOA and agreement was 94% (range 84% - 100%) for the target response. For Kyle, 56% of PR analysis sessions were scored by a second independent observer. The mean proportional IOA scores for the target response was 94% (range 89% - 98%). For Aaron, IOA was scored for 33% of PR analysis sessions and the mean proportional IOA score was 93% for the target response. For Carl, IOA was scored for 33% of

PR analysis sessions. The mean proportional IOA score was 90% (range 82% - 96%) for the target response.

Discrimination training. Only Kyle and Aaron participated in discrimination training. To calculate IOA, a proportion of discrimination training session videos were scored by a second independent observer for each participant. IOA was calculated for consumption responses occurring during S^D and S^Δ interval pairs (i.e., sequences) by dividing total number of S^D and S^Δ interval pairs with agreement by the total number of each type that comprised each discrimination training session, which was fixed at 14, and multiplying this number by 100 for each interval type, respectively. For Aaron, 38% of discrimination training sessions were scored by an independent observed yielding a mean agreement of 98% (range 93% - 100%) for occurrence of the consumption response across S^D and S^Δ interval sequences. For Kyle, 50% of discrimination training sessions were scored for IOA yielding a mean agreement of 96% (range 86% - 100%) for occurrence of the consumption response across S^D and S^Δ interval sequences.

Procedure

Preference assessment. A PSPA, as described by Fisher et al. (1992), was conducted for each participant to identify the primary reinforcer for use in the second-order schedule thinning, PR analysis, discrimination training, and concurrent-chained analysis. The edible item selected across the majority of PSPA trials was used as the primary reinforcer during the subsequent experiments for all participants.

Second-order schedule thinning. The second-order schedule thinning steps were as follows for each participant: FR 1 (FR 2), FR 2 (FR 2), FR 3 (FR 2), FR 4 (FR 2), FR 6 (FR 2), FR 8 (FR 2), FR 10 (FR 2) with exception that a FR 5 (FR 2) thinning step was also included for Aaron and Kyle. This step was removed for all subsequent participants to increase efficiency of

the schedule thinning phase. Extended-chained and brief praise second-order schedules were alternated across sessions throughout the entirety of the schedule thinning phase. These second-order schedules operated such that the CPS or brief praise statement was delivered following every two responses emitted and primary reinforcement was delivered following completion of each second-order schedule. A session was defined as the completion of a single second-order schedule of either schedule type.

At the start of each schedule thinning session, all response materials (e.g., index cards, paperclips, completed response bin), the stimulus board (if conducting a session of the extended-chained condition), and a camera to record the session were set up on a table. The participant sat in front of the response materials, which were covered by a laminated piece of paper, and the experimenter sat across the from the participant. At the start of the session, the experimenter started the session timer and uncovered the response materials. As detailed above, the brief praise statement or CPS, depending on the condition being implemented, was delivered following every two responses emitted by the participant. When the prescribed second-order schedule requirement was met, the final brief praise statement or CPS delivery was immediately followed by the delivery of a primary reinforcer and the session ended. The primary reinforcer delivered at the completion of each second-order schedule was kept out of the participant's sight throughout the session. If responding did not occur for 5-consecutive min, the session was terminated and the next scheduled session was begun.

For Dillon, we observed a decrease in responding during the FR 2 (FR 2) thinning step. To remediate this, starting at session 27, we began to model the response for the participant a single time at prior to the start of each session to facilitate resumption of responding. Model prompts were subsequently faded during the FR 4 (FR 2) fading step as responding increased

and maintained. Starting in the FR 6 (FR 2) thinning step, response rates increased significantly making it difficult for the therapist to accurately track responses and implement the production schedule. As such, the target touching apparatus was extended such that there was a greater distance between the two targets. Specifically, the target touching apparatus was extended to be 123 cm in length with the targets being approximately 106 cm apart. This extended apparatus was used across the remainder of the schedule thinning procedure, PR analysis, and concurrent chains analysis for Dillon.

The criteria to move to the next schedule thinning step were two-fold: (1) at least 3 sessions were conducted across both brief and continuous conditions under each second-order schedule value and (2) response rates were either stable or on an increasing trend across both schedule types. Visual inspection was used to determine whether response rates met these criteria under each schedule value that composed the thinning steps. Participants progressed to the first phase of the study proper, the PR analysis, when responding was maintained at a stable level or an increasing trend was evident at the terminal schedule thinning value of FR 10 (FR 2) across both schedule types.

PR analysis. The second-order schedules that composed the PR were as follows: FR 10 (FR 2), FR 20 (FR 2), FR 40 (FR 2), and FR 80 (FR 2). In other words, the initial second-order schedule of the PR was FR 10 (FR 2) and a geometric progression was implemented across each step of the PR schedule until the terminal FR 80 (FR 2) schedule was reached. PR sessions were terminated if one of the following criteria were met: (1) the participant completed all component schedules of the PR, (2) the breakpoint of 60 consecutive seconds of no responding was met, or (3) if the 30-min session maximum elapsed. The three conditions included in the PR analysis were implemented according to a multielement design.

Sessions were conducted in the same settings and with the same session materials as is described in under the "General Method" section above. The responses, primary reinforcer, brief praise statement, and CPS used in the brief and extended-chained schedules of the PR analysis were also identical to those described in the "Second-order Schedule Thinning" section above for each participant.

At the start of each PR session, the participant sat in front of the covered response materials and across from the experimenter. The response materials were placed on laminated pieces of blue, orange, or pink construction paper which corresponded with the brief, continuous, and tandem conditions of the PR analysis, respectively. The stimuli that served as the targets for the target touching response were also colored in this manner across conditions for Dillon. Sessions started when the experimenter uncovered the response materials. Brief praise statements or the CPS were delivered as described in the "Second-Order Schedule Thinning" methods section above. During tandem sessions, experimenters used digital hand counters to covertly count responses for each second-order component schedule of the PR. Experimenters covered the response materials and delivered primary reinforcement following completion of the second-order schedule of each component schedule comprising the PR. The next second-order schedule started once the participant finished consuming of the reinforcer. The next schedule of the PR was initiated by the experimenter uncovering the response materials. This process continued until the terminal component schedule of the PR was completed, the break point criterion was met, or the maximum session duration elapsed. Visual inspection was used to determine whether response counts were stable across all conditions of the PR analysis. Once response patterns were determined to be stable and no significant overlap between the continuous or brief

condition and the tandem was evident, the participant progressed to the next phase of the study proper.

Discrimination training. The discrimination training procedure was designed to establish stimulus functions for the brief praise statement or CPS if significant overlap was obtained between the brief or continuous condition and the tandem condition of the PR analysis. In other words, such a result would indicate that the response-contingent pairing of these stimuli and primary reinforcement that was a component of the schedule thinning phase of this study was ineffective in establishing these stimuli as conditioned reinforcers. Discrimination training consisted of procedures adapted from those described by Holth et. al. (2009).

The primary reinforcers, brief praise statement, and CPS used in discrimination training were identical to those described in the "General Method" and "Second-order Schedule Thinning" sections above. All sessions of the discrimination training procedure were composed of 14 presentations of a discriminative stimulus (S^D) and S^Δ interval sequence. A sequence was defined as the presentation of an S^Δ interval followed by the presentation of a S^D interval. The presentation of S^D intervals, which conversely determined the duration of the S^Δ interval, initially occurred according to a variable-time (VT) 3 s schedule. The VT 3 s array consisted of 14 intervals ranging from 1 s to 6 s which averaged to 3 s. S^D interval presentations were subsequently faded to a VT 6 s schedule then a VT 12 s schedule contingent on three consecutive responses during the S^D interval of a sequence while no responding occurred during the corresponding S^Δ interval of that sequence. The VT 6 s and 12 s arrays consisted of 14 intervals each ranging from 2 s to 12 s or 4 s to 24 s which averaged to 6 s and 12 s, respectively. All S^D intervals were approximately 4 s in duration across both brief and CPS conditions. Brief praise statements or a full five column by two row stimulus board (i.e., a completed 10 grid board)

served as the stimuli presented during the S^D intervals across the brief and continuous conditions of the discrimination training procedure, respectively. Regardless of which stimulus was shown to be neutral in the PR analysis, both the CPS and brief praise statement were included in the discrimination training procedure to avoid any differential effects increased exposure during this procedure may have on the results of our subsequent comparative analyses. The S^Δ interval for both brief and CPS conditions consisted of the experimenter looking down at the table with a neutral affect with no other programmed stimuli present. The duration of the S^Δ intervals corresponded to the individual arrays that composed the VT schedules that determined the presentation of S^D intervals during training sessions.

Each discrimination training session started with the participant sitting across from the experimenter with 14 primary reinforcers placed in front of the participant within arm's reach. The experimenter used a list showing the array of intervals comprising the VT schedule, which was kept out of sight of the participant, to present each S^D interval across the session. During the initial S^D and S^Δ interval sequences, experimenters prompted the participants to emit a response in the presence of the S^D according to the following prompting hierarchy: (1) immediate gesture cue, (2) 2 s delay gesture cue, (3) independent. The criterion to move to the next step of the prompting hierarchy was prompted or independent consumption responses across three consecutive S^D interval presentations. Any responses during S^Δ intervals were neutrally blocked across the entirety of discrimination training. Discrimination training was terminated when the participant had emitted independent consumption responses during S^D intervals and no responses during S^Δ intervals across two consecutive sessions at the VT 12 s schedule of S^D interval presentation.

Results and Discussion

PSPA

Figure 1 shows results of the PSPA for each participant. For Dillon, as shown in the top left panel, sour cream and onion pop chips were selected the most during the PSPA. Potato chips and cheese crackers were selected across the majority of PSPA trials for Carl as shown in the bottom left panel. We determined to use potato chips during the study proper for Carl. Mini Oreos were selected across the most trials for Aaron and Kyle as shown in the right panels. As such, these stimuli were used as the primary reinforcers for these participants during the second-order schedule thinning, PR analysis, discrimination training, and concurrent-chained schedule analysis.

Second-order schedule thinning

Figures 2 shows responses per minute for both the extended-chained and brief second-order schedules across each schedule thinning step for all participants. The closed triangle and open circle data paths indicate responses per minute across sessions for the CPS and brief praise conditions, respectively. For Dillon, as shown in the top left panel, we observed little or no responding starting on session 27 of the FR 2 (FR 2) thinning step. Following the addition of a model prompt, response rates increased and maintenance of responding was observed following the removal of these prompts at session 72. Significant increases in response rates were then observed across the FR 4 (FR 2), FR 8 (FR 2), and FR 10 (FR 2) schedule thinning steps. Following the extension of the target touching apparatus, response rates decreased and maintained at more practical rates, approximately 60 responses per minute, as shown in the "FR 10 (FR 2) Extended Apparatus phase" of Figure 2 for Dillon.

The bottom left panel of Figure 2 shows responses per minute across both extended-chained and brief second-order schedules for each schedule thinning step for Carl. A general

increasing trend across schedule thinning steps was observed for both schedules. The brief second order schedule became differentiated, producing higher response rates, relative to the extended-chained schedule during the last 2 sessions of the FR 4 (FR 2) second-order schedule through the FR 8 (FR 2) schedule. Response rates then decreased in the brief second-order schedule and produced similar rates of responding as the extended-chained schedule during the terminal FR 10 (FR 2) schedule thinning step. For Aaron and Kyle, response rates produced under the CPS and brief praise conditions are denoted on the top and bottom right panels of Figure 2, respectively. Response rates for both participants were maintained at similar levels across both schedule types with overall increasing trends and no systematic differentiation evident between conditions across all schedule thinning steps.

PR Analysis and Discrimination Training

Figure 3 shows the results of the PR analysis for Dillon and Carl. Response counts for CPS, brief praise, and tandem sessions are plotted on the y- and x-axes of the top and bottom left panels, respectively. Sessions for which the breakpoint criterion was met are denoted by the half-filled circles, half-triangles, and the open circle with dot for the tandem, extended-chained, and brief PR schedules, respectively. As shown in the top left panel of Figure 3, the extended-chained, brief praise, and tandem second-order PR schedule produced the highest, second highest, and lowest response counts for Dillon, respectively. Additionally, the breakpoint criterion was met in all tandem sessions, eight of ten brief praise sessions, and two of ten extended-chained sessions. To provide analysis of responding the second-order component schedules that produced differences in responding across each condition, we generated a response output figure which consists of the aggregate total amount of responses each component schedule produced across the final three sessions of the PR for each condition. The

top right panel of Figure 3 shows these data for Dillon. The close triangle, open circle, and closed circle data paths denote the CPS, brief praise, and tandem conditions, respectively. Similar amounts of responses were maintained under the FR 10 (FR 2) component schedule across each schedule type. Differentiation between the conditions begins to occur at the FR 20 (FR 2) component schedule with the continuous condition producing slightly more responses relative to the brief condition and the tandem condition producing no responses across this and the remaining component schedules comprising the PR. This pattern of differentiation becomes more prominent with the FR 40 (FR 2) and FR 80 (FR 2) extended-chained schedule maintaining differentially more responses relative to the brief second-order schedules of the same parameters. These data show that the differences in response counts, as shown in the top panel, across the continuously present and brief praise conditions occurred primarily across the FR 40 (FR 2) and FR 80 (FR 2) component schedules of the PR schedule with the extended-chained schedule producing more responses in each.

For Carl, as shown in bottom left panel of Figure 3, similar response counts were obtained between both the CPS and brief praise conditions with the completion of the entire PR schedule occurring in the majority of sessions for each. Additionally, the response counts produced by the tandem condition were differentially lower, with breakpoints obtained in every tandem session conducted, relative to the continuous and brief praise conditions across all sessions. Given the significant overlap in response counts produced by the extended-chained and brief praise PR schedules, we concluded the stimuli embedded in these schedules were similarly efficacious in their capacity as conditioned reinforcers and there was no evidence of any response suppression under the extended-chained arrangement. Carl's response outputs across individual component schedules of the PR are shown in the bottom right panel of Figure 3. These

are aggregated from the final three sessions of the PR analysis for each condition. Similar amounts of responding were obtained across each component schedule of the PR for the continuous and brief praise conditions which is expected given Carl's response count results and support the interpretation the stimuli were both functioning as conditioned reinforcers at similar levels of efficacy. The tandem condition produced similar total responses for the FR 10 (FR 2) component schedule but responding subsequently decreased to zero as the component schedule values increased.

Figure 4 shows the results of the PR analysis for Aaron and Kyle, respectively. For Aaron, as shown in the top left panel, an overall decreasing trend in response counts was obtained across all three second-order PR schedules with differentially more responding being produced in the brief second-order PR relative to the CPS and tandem second-order PR schedules across the last four sessions of phase one. Also note the convergence and significant overlap obtained in the response counts produced by the extended-chained and tandem schedules in the first phase for Aaron. Given this overlap, we determined the CPS were not exerting any stimulus function on responding. As such, the PR analysis was discontinued, and Aaron progressed to the discrimination training phase which was designed to establish these stimulus functions.

For Kyle, as shown in the bottom left panel of Figure 4, differentiation was obtained with the extended-chained PR producing higher response counts relative to the brief and tandem PR schedules. That said, significant overlap between response counts produced by the brief and tandem second-order PR schedule was obtained. Also note the break points obtained in two of four sessions for the both the brief and tandem schedules whereas no breakpoint was obtained across the continuous sessions. As such, we determined that the brief praise stimulus, "Amazing

Job," was not exerting a reinforcing stimulus function. Given this, the PR analysis was discontinued with Kyle and discrimination training started.

Results of discrimination training for Aaron and Kyle are shown in the left and right panels of Figure 5, respectively. The top and bottom panels display results of each brief and continuous discrimination training session for each participant. The closed and open circles indicate the proportion of consumption responses that were independent and prompted during S^D intervals, respectively, whereas the closed triangle data path shows the proportion of attempted consumption responses during S^Δ intervals across each training session. For Aaron, the consumption response was prompted in a proportion of 0.21 of S^D intervals and independent consumption responses occurred in 0.79 of S^D intervals during the first brief discrimination training session. Independent consumption responses were observed across all subsequent S^D intervals in the remaining three discrimination training sessions. A single attempt to access the primary reinforcers occurred in an S^Δ interval during the second brief stimulus discrimination training session which was blocked by the therapist. Similar proportions of S^D intervals with independent and prompted consumption responses were obtained across continuous discrimination training sessions for Aaron. During the first continuous discrimination training session, prompted and independent consumption responses occurred in a proportion of 0.21 and 0.79 S^D intervals, respectively. The proportion of S^Δ intervals for this discrimination training session was 0.07. Independent consumption responses occurred across all S^D intervals and during S^Δ intervals throughout the final three discrimination training sessions for Aaron.

As shown in the top right panel of Figure 5, in the first brief stimulus discrimination training session for Kyle, the consumption response was prompted in a proportion of 0.21 of S^D intervals and independent consumption responses occurred in a proportion of 0.79 S^D intervals.

The proportion of S^D intervals with independent consumption responses increased to 0.93 during the second discrimination training sessions and further increased to 1.0 of S^D intervals during the final two sessions. During first and second discrimination training sessions, the proportion of S^Δ intervals for which attempts to access the primary reinforcers occurred was 0.22 and 0.14 respectively. No attempts to access the primary reinforcer occurred during S^Δ intervals across the final two discrimination training sessions.

The bottom right panel of figure 5 shows results for Kyle's continuously present discrimination training sessions. In the first session, the proportion of S^D intervals with prompted and independent consumption responses was 0.38 and 0.62, respectively. During the second continuous discrimination training session, the proportion S^D intervals with prompted and independent consumption responses was 0.86 and 0.14, respectively. Independent consumption responses occurred across all S^D intervals during the final two training sessions. No attempts to access the primary reinforcers occurred during S^Δ intervals of across these sessions. Discrimination training was discontinued, and the PR analysis reinitiated following two consecutive sessions with independent consumption responses during S^D intervals and no attempted consumption responses during S^Δ intervals for both Aaron and Kyle.

The results of the PR analysis post-discrimination training for Aaron and Kyle are shown in phase two of top and bottom left panels of Figure 4, respectively. Differentiated response counts were obtained across continuous, brief praise, and tandem conditions for Aaron. Specifically, the relatively highest amount of responding, albeit by a small amount, was obtained in the continuous PR condition, the second highest response counts were obtained in the brief PR condition, and the least amount of responding occurred in the tandem PR condition. Further, the

breakpoint criterion was met in three out of six tandem PR sessions whereas the breakpoint criterion was not met in any CPS or brief praise PR sessions.

The PR analysis results post-discrimination training for Kyle show the highest, second highest, and lowest response counts were obtained in the continuous, brief praise, and tandem PR conditions, respectively. In addition, breakpoints occurred in two of four tandem sessions whereas the breakpoint criterion was not met across any continuous or brief PR sessions.

The top right and bottom right panels of Figure 4 show the response outputs, aggregated across the final 3 sessions of the PR analysis, for each second-order component schedule across each condition for Aaron and Kyle, respectively. For Aaron, similar response totals were produced under the FR 10 (FR 2) for the continuous, brief praise, and tandem conditions. Under the FR 20 (FR 2), the continuous and praise conditions continued to produce the same amount of responding whereas the tandem condition produced slightly less. The largest differentiation in response outputs occurred at the FR 40 (FR 2) second-order schedule with the most responding produced under the extended-chained schedule, slightly less in the brief second-order schedule, and the least in the tandem schedule. Aaron did not reach FR 80 (FR 2) component schedule of the PR across any condition.

For Kyle, the FR 10 (FR 2) component schedule produced the same amount of responding across all conditions. Differentiation between the continuous and brief praise condition relative to the tandem condition begins to emerge under the FR 20 (FR 2) component schedule with identical response outputs produced in the former conditions and a slightly lower response output produced in the latter. This differentiation became more significant under the FR 40 (FR 2) component schedule with the continuous and brief conditions producing about 200 more responses relative to the tandem condition. At the terminal PR schedule component of FR

80 (FR 2), the continuous condition had a significantly higher response output relative to both the brief and tandem conditions with the brief condition having just a slightly higher response output compared to the tandem. Following stable differentiated responding across CPS, brief, and tandem PR conditions, as determined via visual inspection of response counts, this analysis was concluded.

To summarize, three of four participants demonstrated higher response counts under the extended-chained PR schedule of reinforcement relative to the brief and tandem PR schedules. Whereas this is the first demonstration of CPS maintaining more responding relative to brief conditioned reinforcers with a clinical population, it fails to replicate basic findings showing early component response suppression. If this effect was evident in early components of the extended-chained schedule, we would also expect increased PRPs in these components triggering relatively earlier breakpoints in the continuous condition. This is surprising particularly given relatively larger parameter values, specifically FR 40 (FR 2) and FR 80 (FR 2), included in the PR and considering this effect occurred at relatively larger response requirements in findings of basic research. Additionally, two of four participants required discrimination training in order for the CPS and brief praise to exert a reinforcing function which provides evidence the response-contingent pairing which occurred during the second-order schedule thinning phase failed to establish these stimuli as conditioned reinforcers. Whereas the primary purpose of the present experiment was the evaluation of the differential effects continuously present and brief stimuli embedded within the extended-chained and brief praise PR schedules, respectively, there other aspects of conditioned reinforcers that are important to evaluate, specifically preference and relative durability. These measures are particularly relevant to practitioners and further evaluation of them increase the comprehensiveness of our comparative analyses across these

conditioned reinforcer types. Experiment 2 was designed to evaluate the participant's preference for and relative durability of continuously present and brief praise conditioned reinforcers.

Experiment 2

This experiment is composed of two analyses, the concurrent-chained and reinforcer durability analysis. The concurrent-chained schedule choice analysis was designed to determine the participant's preference for either the extended-chained, brief, or tandem second-order schedules of reinforcement experienced during the PR analysis. The procedures used in this analysis were adapted from Luczynski and Hanley (2010). The second analysis of experiment 2 consisted of the conditioned reinforcer durability analysis. The purpose of this analysis was to evaluate if the CPS or brief praise statements would differentially maintain responding in the absence of primary reinforcement. In other words, this analysis was designed to test if the CPS or brief praise statement would differentially retain their reinforcing efficacy across sessions for which the primary reinforcement contingency was removed and only these conditioned reinforcers were delivered contingent on responding. A novel response was used across all participants which was taught solely using the contingent delivery of the CPS or brief conditioned reinforcers to demonstrate the continued reinforcing efficacy of these stimuli. In addition, the use of a novel response may have allowed for a more efficient demonstration of any differential effect in durability across conditioned reinforcer types because this response was not associated with an extensive history of primary reinforcement.

Method

Response Measurement and Dependent Variables

Concurrent-chained analysis. The primary DV of concurrent chained choice procedure consisted of frequency of initial link selection responses across free-choice trials. A selection

response was defined as touching one of initial-link stimuli that were arranged in the concurrent-choice array during a free choice trial.

Reinforcer durability analysis. A novel sorting response was used as the target response. The sorting response was defined as picking up and placing a colored disk into the bin which corresponded to that color. If multiple discs of the same color were picked up and placed in the bin simultaneously, only a single response was scored. No response was scored if multiple-colored discs of differing colors were picked up and placed in a bin simultaneously. Due to the concerns with automatically maintained behavior with response materials (i.e., continuously manipulating paperclips and colored discs) that disrupting free operant responding for Dillon, an alternative response consisting of inserting index cards into a slot on top of a box was used. Index card stuffing was defined as picking up one or more index cards from a stack and inserting them through the threshold of a slot positioned at the top of a 28 cm x 38 cm x 13 cm cardboard box covered in black construction paper. This was also the target response used for Carl given some of the fine motor challenges he experienced with the paperclipping response during the schedule-thinning phase of the present study. All other procedures implemented with Dillon and Carl were identical to the other participants. The primary dependent variables of this phase were the response count per session, cumulative responses during each condition across sessions, total duration response materials were available each session, and ratio breakpoint.

Interobserver Agreement

Concurrent-chained analysis. A second observer independently scored participant's free choice selections via recorded videos of the concurrent-chained schedule choice analysis sessions. IOA was calculated by dividing the total number of initial-link free choice trials scored with the same selection by the total number of free choice trials scored and multiplying this

number by 100. For Dillion, IOA was scored 33% of free choice trials across all phases and 100% agreement on selections was obtained. For Aaron, IOA was scored 100% of free choice trials and 100% agreement on initial-link selections was obtained. For Kyle, IOA was scored by a second independent observer for 100% of free choice trials and 100% agreement on selections was obtained. For Carl, 42% of free choice trials were scored by a second independent observer and 100% agreement for initial-link selections was obtained.

Reinforcer durability analysis. IOA was calculated for target responses across continuous, brief praise, and extinction sessions using the same proportional IOA calculation as is described in the "Second-Order Schedule Thinning" section above for each participant. For Dillon, 34% of sessions were scored and proportional IOA for the target response was 95% (range 90% - 100%). For Kyle, 55% of conditioned reinforcer durability sessions were scored with a proportional agreement measure of 91% (range 83% - 98%) for the occurrence of the target response. Aaron had 33% of his conditioned reinforcer durability sessions scored by a second independent observer. A proportional IOA score of 94% (range 88% - 100%) was obtained for the occurrence of the target response. Carl had 32% of his conditioned reinforcer durability sessions scored by a second independent observer. A proportional IOA score of 97% (range 91% - 100%) was obtained for the target response.

Procedure

Concurrent-chained analysis. All initial link selections were followed by a terminal link for which the participants responded under the second-order schedule type which corresponded to their initial link selection**.** The colored pieces of construction paper or the touch targets that were correlated with each second-order schedule type during the schedule-thinning procedure and PR analysis (i.e., blue, orange, and pink for brief, extended-chained, and tandem second-

order schedules, respectively) were presented equally spaced in a three-choice array at the start of each choice trial which served as the initial link of the concurrent-chain. Each concurrent-chained session started with three forced choice trials during which the experimenter presented the three-choice array consisting of the laminated blue, orange, and pink pieces of construction paper, stated “Pick one”, and immediately provided a gesture prompt for the participant to select one of the pieces of construction paper. We prompted the selection of the stimulus associated with each of type of second-order schedule across these three forced choice trials and the order of which schedule was prompted during forced exposure trials was counterbalanced across sessions. Following the forced choice trials, free choice trials were implemented during which the choice array was presented, the experimenter stated “pick one”, and FR 10 (FR 2) second-order schedule of reinforcement that corresponded to the selected initial-link stimulus was implemented. Each trial, free or forced choice, ended when the FR 10 (FR 2) schedule was completed and primary reinforcer was delivered. Selection stimuli were rotated across each free choice trial. As in Luczynski and Hanley (2010), concurrent-chained schedule choice sessions continued until one of the second-order schedule types was selected four instances more across free-choice trials relative to the other second-order schedules. Participants progressed to next phase of the study proper, the reinforcer durability analysis, when this stability criterion was met.

For Dillon, multiple phases across the 3-choice array and a modified concurrent-stations choice procedure were conducted. The results of the first phase, as detailed below, showed multiple tandem initial-link selections relative to the initial-link selections of stimuli associated with the extended-chained and brief schedules. Given that we obtained preference for the tandem schedule, at odds with the findings for Dillon from experiment 1, we repeated the analyses with some systematic modifications to the procedure. Novel selection stimuli were introduced for

each initial link of the array. These were green, purple, and turquoise laminated pieces of paper measuring 21.59 cm by 27.94 cm, associated with the extended-chained, brief, and tandem second-order schedules, respectively. During this phase, experimenters noticed that the initial-link selection response being emitted by the participant was topographically similar to the target touching response previously reinforced during the during second-order schedule thinning and PR analysis (i.e., the participant would always touch the left-most initial-link stimuli first followed by immediate attempts to touch each of the remaining stimuli of the array, sequentially). This selection response pattern produced undifferentiated initial-link selections across the three second-order schedule choice options.

Given the disruption to the initial-link selections of the current-chained analysis when arranged in a three-choice array, the arrangement of the concurrent-chained choice analysis was modified for Dillon such that the choice array consisted of three separate stations that were arranged at the center of each wall of the session room. Each station consisted of a table, chair, and the green, purple, and turquoise laminated colored stimulus used in the previous concurrent-chained choice arrangement placed on top. In addition to the laminated colored stimuli, tablecloths which corresponded to the color of the laminated stimulus were draped over the surface each station in an effort to increase saliency of the stimuli associated with each second-order schedule type. Choice stations were equidistant from the participant's location at the start of each free choice trial and the schedules associated with each station was rotated across each free choice trial. Following forced exposure to the second-order schedule associated with each station, free choice trials were begun for which the experimenter prompted the participant to "pick one." The selection response during these free-choice trials consisted of the participant approaching a station and touching the stimulus associated with the second-order schedule type.

This selection response was topographically dissimilar to the target touching response used in the prior analyses of the present study and was designed to attenuate the concerns which occurred during the three-choice array arrangement. The FR 10 (FR 2) second-order schedule of reinforcement was implemented contingent on each selection response. Once the stability criterion was met in this concurrent-stations phase, novel initial-link stimuli were introduced and we attempted to replicate the results of concurrent-station choice arrangement.

Reinforcer durability analysis. The progressive-ratio requirements of this phase were identical to those of the PR analysis including geometric progression of the ratio steps following the completion of each ratio requirement within a session. An extinction condition, which operated identical to the tandem condition of the PR analysis with the exception that no primary reinforcement was delivered following completion of each ratio, served as a comparison condition for responding under the continuous and brief praise conditions of this analysis. The novel response, the sorting of two different colored discs into two corresponding bins or index card stuffing (Dillon and Carl only), was used in this phase which was trained during the initial sessions of each condition using a progressive 2 s delay prompting hierarchy that consisted of the following prompt steps: (1) immediate manual guidance, (2) 2 s delayed manual guidance, (3) 4 s delayed manual guidance, (4) independent. Brief praise statements or a CPS, depending on the condition being implemented, were delivered contingent on every 2 prompted or independent responses. The criterion to move to the next prompt step was the completion of three first order components with correct independent or prompted responses. The continuous, brief praise, and extinction conditions of this phase were implemented according to a multielement experimental design.

Conditioned reinforcer durability sessions started with the therapist and participant sitting across from each other at a table with the response materials placed immediately in front of the participant. At the start of the session, the therapist uncovered the response materials and started the session timer. In the brief and continuous conditions, either a brief praise statement or a CPS was delivered contingent on every two sorting or stuffing responses. No stimulus change was delivered contingent on responding during extinction sessions. When the second-order ratio requirement was met, the experimenter covered the response materials and implemented a 10 s inter-ratio interval before implementing the next ratio prescribed ratio of the session. Sessions continued until the 1 min breakpoint criterion was met, the participant completed each ratio requirement of the ratio schedule progression, or the 30 min session max was met. Experimenters visually inspected of the amount of responding being maintained (both response counts and cumulative responses across sessions) under each condition to determine any differential effects. Conditioned reinforcer durability sessions continued until clear differentiation between the brief praise or continuous condition relative to the extinction condition was obtained or if no clear differentiation across conditions was obtained and extinction across all conditions was evident.

For Aaron, we made a modification to the reinforcer durability procedures given that we initially did not observe differentiated responding across conditions and responding maintained in the absence of primary reinforcement indicating that the novel color sorting response may have been maintained by automatic reinforcement. To facilitate differentiation across conditions for Aaron, we made an alternative source of positive reinforcement concurrently available during sessions. A PSPA was conducted to identify a source of positive reinforcement to make concurrently available during conditioned reinforcer durability sessions. Based on the results of this PSPA, a kindle was identified as the source of primary reinforcement experimenters would

make concurrently available. This was placed within arm's reach of the participant and adjacent to the response materials.

Results and Discussion

Concurrent-chained analysis. Figure 6 displays the results of the concurrent schedule choice analysis for all participants. For Dillon, as show in the top left panel, the first phase resulted in differentially more initial-link selections for the second-order tandem schedule. Phase two for Dillon shows the results of the three-choice array choice arrangement with novel stimuli associated with each of the three second-order schedules. Under this concurrent-chained arrangement, undifferentiated choice responding was obtained across all initial-link selections.

The results of the station concurrent-chained arrangement, as shown in phase three of the top left panel in Figure 6, indicate a preference for the brief second-order schedule of reinforcement. Initial-link selections for both the extended-chained and tandem second-order schedules also occurred during this phase prior to responding becoming differentiated with seven consecutive brief second-order schedule selections across the final free choice trials of this phase. The final phase for Dillon shows the results of the concurrent-chained schedule analysis with choice stations and novel initial-link stimuli. Following a single selection of the extended-chained schedule, exclusive selections of the initial-link associated with the brief-second-order schedule occurred replicating the results of the previous phase.

For Carl, the results of the concurrent-chained choice analysis are shown in the bottom left panel of Figure 6. Differential selections of the initial link corresponding to the tandem second-order schedule terminal link occurred across the first 10 free choice trials. Subsequently, multiple selections of the initial link corresponding to the brief second-order schedule occurred resulting in both the tandem and brief second-order schedules being selected across the same

number of free choice trials, seven, relative to extended-chained schedule which was selected across a total of three free choice trials. We concluded that Carl's preference across the brief and tandem second-order schedules was indifferent given these results. That said, it is notable that the tandem second-order initial link was differentially selected relative to the extended-chained schedule choice option.

The top right panel of Figure 6 shows the results of the concurrent-chained analysis for Aaron. Following one selection of tandem schedule, exclusive selections of the extended-chained schedule were observed indicating preference for the extended-chained schedule. The results of the concurrent-chained analysis for Kyle are displayed on the bottom right panel of Figure 6. Initially, two selections for the brief second-order schedule occurred which were followed by a single selection of the extended-chained and tandem schedules prior to four consecutive selections of the brief second-order schedule. This indicates Kyle's preferred the brief second-order schedule of reinforcement. Participants progressed to the reinforcer durability analysis following identification of second-order schedule preference.

Reinforcer durability analysis. The top and bottom panels of Figure 7 shows the response count and cumulative response results of the conditioned reinforcer durability analysis for Dillon and Carl, respectively. The closed triangle, open circle, and closed circle data paths denote response counts across the continuous, brief praise, and extinction conditions, respectively. As shown in the top left panel, the continuous condition produced the most responding in the first session compared to both brief praise and extinction conditions for Dillon. As sessions progressed, however, response counts in the brief condition increased resulting in differentially more responding relative to the continuous condition in four of the next five sessions (sessions 2 through 16) before decreasing to similar levels and eventually extinguishing

during the last two sessions. A similar response count pattern was observed in the extinction sessions with the first three sessions producing relatively low response counts which subsequently increased for the next three sessions of this condition (sessions 12, 15, and 17) before decreasing to zero levels for the final three sessions. Further, when examining the number of sessions that met the breakpoint criterion across conditions, the brief praise condition met the breakpoint in the least number of sessions, seven of eleven, relative to the continuous and extinction conditions which had breakpoints in nine of eleven and eight of ten sessions, respectively.

The top right panel of Figure 7 shows a cumulative record of responses across sessions for each condition of the conditioned reinforcer durability analysis for Dillon. As observed in the initial response count results, the continuous condition produced most the most cumulative responses in the initial session prior to five consecutive sessions with relatively low responding. Differentiation between the brief praise condition relative to both the continuous and extinction conditions quickly emerged with the brief praise condition producing the highest cumulative responses from session 11 through the remaining sessions of the analysis. The continuous and extinction conditions produced a similar amount of cumulative responding across the durability analysis.

Taken together, the response count, cumulative record, and breakpoint data show that the brief praise condition maintained the most responding and produced the least number of breakpoints across entirety of the conditioned reinforcer durability analysis when compared to the continuous and extinction conditions for Dillon. As such, the brief praise conditioned reinforcer was determined to be relatively more durable compared to the CPS. Further, when examining the raw data, experimenters noticed the response counts and responses per minute

produced during sessions 4 through 16 were relatively higher in the brief praise and extinction conditions compared to the continuous condition which may indicate that the CPS were suppressing responding. It is possible that these stimuli began suppressing responding following the initial sessions of the conditioned reinforcer durability analysis for which they were no longer paired with primary reinforcement. The fact that differentially more breakpoints, nine, were obtained in the continuous condition relative to the brief and extinction conditions which had seven each also support this interpretation. Future research should determine whether CPS differentially lose their reinforcing efficacy more rapidly than brief conditioned reinforcers when no longer paired with primary reinforcement.

The bottom left panel of Figure 7 shows the conditioned reinforcer durability analysis response count results for Carl. As denoted by the half-filled triangles, open circle with dot, and half-filled circles, the breakpoint criterion was met in each session conducted in this analysis across all conditions. Relatively higher response counts were obtained in the continuous condition relative to the brief praise and extinction conditions across the initial three sessions of each condition (sessions 1 through 9). A decreasing trend in response counts of the continuous condition is evident starting at session 10 which continued throughout the remainder of the analysis resulting in significant overlap between this condition and the brief praise and extinction conditions. The final five sessions of this analysis show no responding across the continuous, brief, or extinction conditions indicating the continuously present and brief praise stimuli were no longer functioning as conditioned reinforcers.

Carl's cumulative response across sessions for the continuous, brief praise, and extinction conditions of the reinforcer durability analysis are displayed in the bottom right panel of Figure 7. The initial session produced similar cumulative responses across all sessions. As sessions

progressed, differentiation occurred in the cumulative responses of the continuous condition relative to the praise and extinction conditions. A total of 111 and 200 more responses were produced in the continuous relative to the extinction and praise conditions, respectively. Interestingly, the extinction condition of the reinforcer durability analysis produced 89 more cumulative responses relative to the brief praise condition. The majority of responses which contributed to this difference occurred in session 23, an extinction session for which 61 responses occurred. Differentially lower responses also occurred in the brief condition during sessions 7 through 14 relative to the extinction condition. This may indicate that the brief stimuli began suppressing responding after the initial two sessions of this analysis. Taken together, the response count and cumulative record results of Carl's reinforcer durability analysis indicate the CPS were more durable conditioned reinforcers relative to brief praise.

The results of the conditioned reinforcer durability analysis for Aaron and Kyle are displayed in the top and bottom panels of Figure 8, respectively. As shown in the first phase of in top left panel of Figure 8, undifferentiated responding across conditions was obtained and responding maintained for each in the absence of primary reinforcement. The second phase in the top left panel of Figure 8 shows the results of the concurrent positive reinforcement arrangement for Aaron. Initially, we began obtaining lower response counts and break points across each condition of the analysis. As sessions progressed, response patterns showed that responding maintained at similar levels for both CPS and brief praise conditions whereas consistently lower response counts were obtained in the extinction condition indicating that the continuously present and brief stimuli were continuing to reinforce or occasion responding for Aaron. Additionally, breakpoints were reached in each extinction, three of seven brief praise, and two of

seven continuous sessions providing additional evidence that each conditioned reinforcer type was equally durable for Aaron.

The top right panel of Figure 8 shows cumulative responding across conditions for Aaron. Similar cumulative responses across sessions were obtained across all conditions of the initial phase of this analysis for Aaron. During the second phase with the concurrently available source of positive reinforcement relatively more responding across sessions in the continuous and brief praise conditions relative to the extinction condition. Taken together, all dependent measures indicate the CPS and brief praise conditioned reinforcers were equally durable for Aaron. Though, there was one more breakpoint obtained in the brief praise relative to continuous condition.

The bottom left panel of Figure 8 shows the results of the conditioned reinforcer durability response count results for Kyle. The CPS condition maintained the highest response counts, the brief praise condition the second highest, and extinction the lowest when considering the entirety of this analysis although some overlap across conditions did occur during sessions 7 through 12. In addition, there were differentially more breakpoints across the brief and extinction sessions relative to the continuous condition. The breakpoint criterion of 1 min of no responding was met in six of eight brief praise, five of seven extinction sessions, and none of the continuous sessions. The bottom right panel of Figure 8 shows the cumulative responses across sessions for each condition of the conditioned reinforcer durability analysis for Kyle. The continuous condition reliably produced more cumulative responses throughout the entire analysis relative to the brief praise and extinction conditions. As such, the response count, breakpoint, and cumulative record measures support the interpretation that the CPS conditioned reinforcer was more durable relative to the brief praise conditioned reinforcer for Kyle.

General Discussion

The present study was informed and designed from two lines of basic research on the effects continuously present and brief conditioned reinforcers have on free operant responding. In regard to the basic findings of FR token and extended-chained schedules of reinforcement, there are multiple demonstrations of early component response suppression (see Bullock & Hackenberg, 2015; Foster et al., 2001; Jwaideh, 1973 for demonstrations of this effect). In regard to the basic findings for brief conditioned reinforcers, Findley and Brady (1965) and Malagodi et al. (1973) demonstrated the response enhancing effect the addition of these conditioned reinforcers may have when embedded within second-order schedules of reinforcement. As such, the analyses comprising the present study were designed to elucidate any differential effects of CPS and brief praise on the behavior of humans under clinically common schedules as well as provide empirical evidence on the preference and durability of CPS and brief conditioned reinforcers.

For three of four participants, the continuously present stimuli embedded in the extended-chained PR schedule of reinforcement produced the more responding relative to the brief second-order PR schedule. These results are in direct contrast with both lines of basic research on these types of conditioned reinforcers. That said, there are a number of variables which may have contributed to the differences in results obtained. First, procedural differences across experiments may have contributed. For example, basic studies showing early component response suppression under chained and token schedules and the response optimizing effect of brief stimuli showed these effects under fixed schedule values with responding at steady state. It is possible that the PR schedule implemented in the present study may have prevented steady state responding to be established within each component schedule of the PR given that participants

were exposed to each a single time per session. In fact, a post-hoc analysis of the pausing patterns within the components composing the PR across the last three sessions of each condition (i.e., extended-chained, brief praise, and tandem) supports this hypothesis. In other words, no order was obtained when examining average PRPs across components of the second-order schedules across all conditions across participants. If order was obtained in the pausing data, it would indicate that behavior was at steady state within each component schedule of the PR analysis. Further, we designed the PR analysis such that the breakpoint criterion would potentially capture relatively longer pausing that has been demonstrated to occur during early component response suppression. The fact we did not obtained orderly PRPs may have contributed to the differences in our results relative to those of basic literature. Future research should evaluate steady state responding across extended-chained and brief stimulus schedules via a parametric analysis to determine if the functional relations identified in the present study hold. In addition, future research may identify boundaries of generality of the response suppressive or response optimizing effects demonstrated in the basic token and brief conditioned reinforcement research.

The concept of the transitive conditioned motivating operation (CMO-T) may provide a lens for interpretation of the results obtained in the PR analysis of the present study (Michael, 2000). A CMO-T is a conditioned motivating operation for which the stimulus function exerted by a stimulus is altered due to that stimulus' association with the availability of reinforcement for a response (Michael, 2000). The full stimulus board, which was the final stimulus of the stimulus complex that was always paired with primary reinforcement, may have been established as reinforcing, resulting in more consistent responding under the extended-chained schedule of reinforcement. This is a unique interpretation of conditioned reinforcement and how fixed

arrangements of stimuli, such as tokens, within schedules of reinforcement may come to function as reinforcers. Future research should evaluate the role CMO-Ts may have in the maintenance of responding under token and extended-chained schedules of reinforcement.

Another limitation of the present study that may also have contributed to the differences between our results and those of previous basic research is the difference in stimulus modality of the CPS and brief praise. It is possible that the visual modality of the CPS was more salient than the auditory praise, resulting in more behavior being produced under the extended-chained PR schedule. The differential effects on behavior as function of differences in stimulus modality of conditioned reinforcers should be evaluated in future research. Relatedly, some individuals diagnosed with an autism spectrum disorder or other learning impairment may be less sensitive to social stimuli and may present with a variety of social deficits (American Psychiatric Association, 2013; Lovaas et. al. 1966; Theobold & Paul, 1976). As such, it is possible the results of the present experiment were affected in that the non-social continuous stimuli were more salient relative to social praise stimulus to the participants given the nature of their disability. Future research should conduct a systematic replication of the present experiment with typically developing as well as individuals diagnosed autism spectrum or related disabilities in order to determine whether the efficacy of social stimuli serving as conditioned reinforcers are differentially affected in this population. An additional limitation of the present study is that participants may have had different histories of reinforcement associated with each conditioned reinforcer type examined. Whereas we were able to control for the participant's proximal histories and experience with the continuously present and brief conditioned reinforcers used by providing identical amounts of exposure to each, it is unknown whether the participants had differential experiences with these stimuli across their learning histories. Future research should

attempt to use unique, novel token and brief conditioned reinforcers in order to control for any history effects. Last, the use of different target responses may also be considered a limitation in that it could be considered an additional IV given how dissimilar the paper clipping and target touching responses were. We did obtain a single intersubject replication of the extended-chained PR schedule producing the most responding across the paper-clipping and target touch responses. That said, Carl's results demonstrated that both the continuously present and brief stimuli produced similar amounts of target touching which deviated from the findings of the other participants, particularly the two for which the paper clip response was used. Future research should evaluate the effect response topography and response effort has on the stimulus functions or relative efficacy of continuously present and brief stimuli embedded within second-order schedules.

Discrimination training was required for two of the four participants in order for the CPS, in the case of Aaron, and brief praise, in the case of Kyle, to function as reinforcers. This indicates that the response contingent pairing of these stimuli that occurred in the schedule thinning phase was not sufficient in establishing a reinforcing stimulus function. The present results represent a systematic replication of Holth et al. (2009) by demonstrating that stimuli which are established as discriminative for the availability of reinforcement (i.e., S^Ds) may subsequently function as conditioned reinforcers. That said, additional replications of the discrimination training procedures should be conducted as the present study had only a single, intersubject replication of this effect. Given these results, practitioners should be cautious of using stimuli assumed to be conditioned reinforcers in skill acquisition or behavior management programs even following respondent pairing and/or response-contingent pairing procedures as they may not be exerting a reinforcing function. Whereas the PR analysis was used, in part, as an

assessment of the reinforcing efficacy of the CPS and brief praise in the present study, additional conditioned reinforcer efficacy assessments that are more efficient should be examined in future research. If a practitioner does in fact discover that a stimulus they are attempting to utilize as a conditioned reinforcer is not exerting the proper stimulus functions, discrimination training using procedures similar to those described in the present experiment may be an efficient method of establishing a conditioned reinforcing function. That said, additional research on the relative efficacy and efficiency of methods, such as stimulus-stimulus pairing, response-contingent pairing, or discrimination training, for establishing conditioned reinforcers is needed.

Mixed correspondence was obtained across participants between the concurrent-chained analysis and the PR analysis. For Aaron, the extended-chained schedule was preferred and was also the second-order schedule type that produced the most responding during the PR analysis. For Carl, the indifference between the brief and tandem second-order schedules were not in agreement with the PR analysis which demonstrated that the extended-chained schedule and brief PR schedules maintained similar amounts of responding. The results of the concurrent-chained analysis for both Kyle and Dillon indicate preference for the brief second-order schedule, which contrasts with their PR analysis results. These results in fact replicate previous research on the non-correspondence between the results PR schedules and other traditional measures of reinforcing efficacy such as preference determined under concurrent-choice arrangements (Johnson & Bickel, 2006). It is possible that other measures of relative reinforcing efficacy, such that those used in behavioral economics (e.g., elasticity, O_{max}, P_{max}, etc.) would result in more agreement and better unify the results of the present analyses, but these measures require steady state responding across each schedule value for each condition in order to be accurately calculated. As described above, the PR schedule may have not allowed for responding

to come to steady state within the individual component schedules comprising the PR. Future research may evaluate whether behavioral economic measures, generated from a parametric analysis of different types of conditioned reinforcement schedules at steady state, result in increased correspondence across analyses similar to those included in the present study. In addition, we did not implement the entire PR schedule following the initial-link selections during the concurrent choice analysis, and it is likely that this may have affected the preferences obtained as well as their correspondence with the results of the PR analysis. Specifically, it is possible that preferences would better correspond to the PR analysis if the entire PR schedule was implemented in the terminal link following the initial-link selection response during the concurrent-chained procedure. This interpretation is supported by the results of the response output figures showing similar amounts of responding maintained at the FR 10 (FR 2) across all second-order schedule types. Future research should evaluate whether preference shifts between schedule types occur as parameter values are systematically manipulated in a concurrent-chained arrangement.

The conditioned reinforcer durability analysis also produced mixed correspondence across participants when compared to the results of the PR analysis. Correspondence was obtained for Aaron in that the brief and CPS maintained comparable amounts responding, with the brief praise condition producing differentially more breakpoints in the absence of primary reinforcement, which was similar to the pattern observed in the PR analysis. For Kyle, the continuous condition maintained the most responding in the absence of primary reinforcement which is also the schedule type that produced the most responding in the PR analysis. In contrast, Carl and Dillon's response patterns in the reinforcer durability analysis did not correspond with the results of their respective PR analyses. The continuous and brief praise conditions produced

the most responding during the durability test for Carl and Dillon, respectively, whereas the continuously present and brief praise stimuli maintained similar amounts of responding during the PR for Carl and the CPS produced the most responding during the PR analysis for Dillon. As such, the results of the PR analysis accurately predicted the relative durability of conditioned reinforcer types in two of four participants. Additional research is needed to evaluate whether the second-order schedule arrangements comparing responding maintained by continuous or brief conditioned reinforcers will accurately predict the relative durability of conditioned reinforcers. The differences in stimulus modality, as discussed relative to the results of the PR analysis above, may have also contributed to the results of the durability analysis. As such, future research should also examine whether a functional relation between conditioned reinforcer modality and resistance to extinction exists. It is possible that differences in stimulus modality are related to differential saliency of the CPS and, as such, resulted in the extended-chained schedule maintaining more responding the absence of primary reinforcement outright for two participants and at similar levels as the brief condition for one.

Taken together, the results of the translational analyses comprising the present study represent unique contributions to the applied line of research on continuously present and brief conditioned reinforcers. To our knowledge, this is the first demonstration showing continuously present conditioned reinforcers producing more responding relative to praise with human participants despite the common use of these conditioned reinforcers in practice. These results are at odds with the basic research showing early-component response suppression under relatively large second-order token or extended-chained schedules and the response enhancing effect the addition of brief conditioned reinforcers when embedded within second-order schedules which exemplifies the need for additional research on conditioned reinforcement.

These results highlight the gap between the basic and applied research on conditioned reinforcers and represent the potential bidirectional translational research has in filling these gaps. Specifically, future bidirectional translational research may help identify boundaries of generality of these functional relations, facilitate the development of the optimal method of establishing conditioned reinforcers, and identify additional contextual or parametric variables that influence the stimulus functions, concurrent choice, and relative durability of conditioned reinforcers. Empirical analyses that contribute to filling these gaps should provide behavior analysts with a more comprehensive understanding of the concept of conditioned reinforcement which, in turn, will assist practitioners in optimizing conditioned reinforcer systems for their clients.

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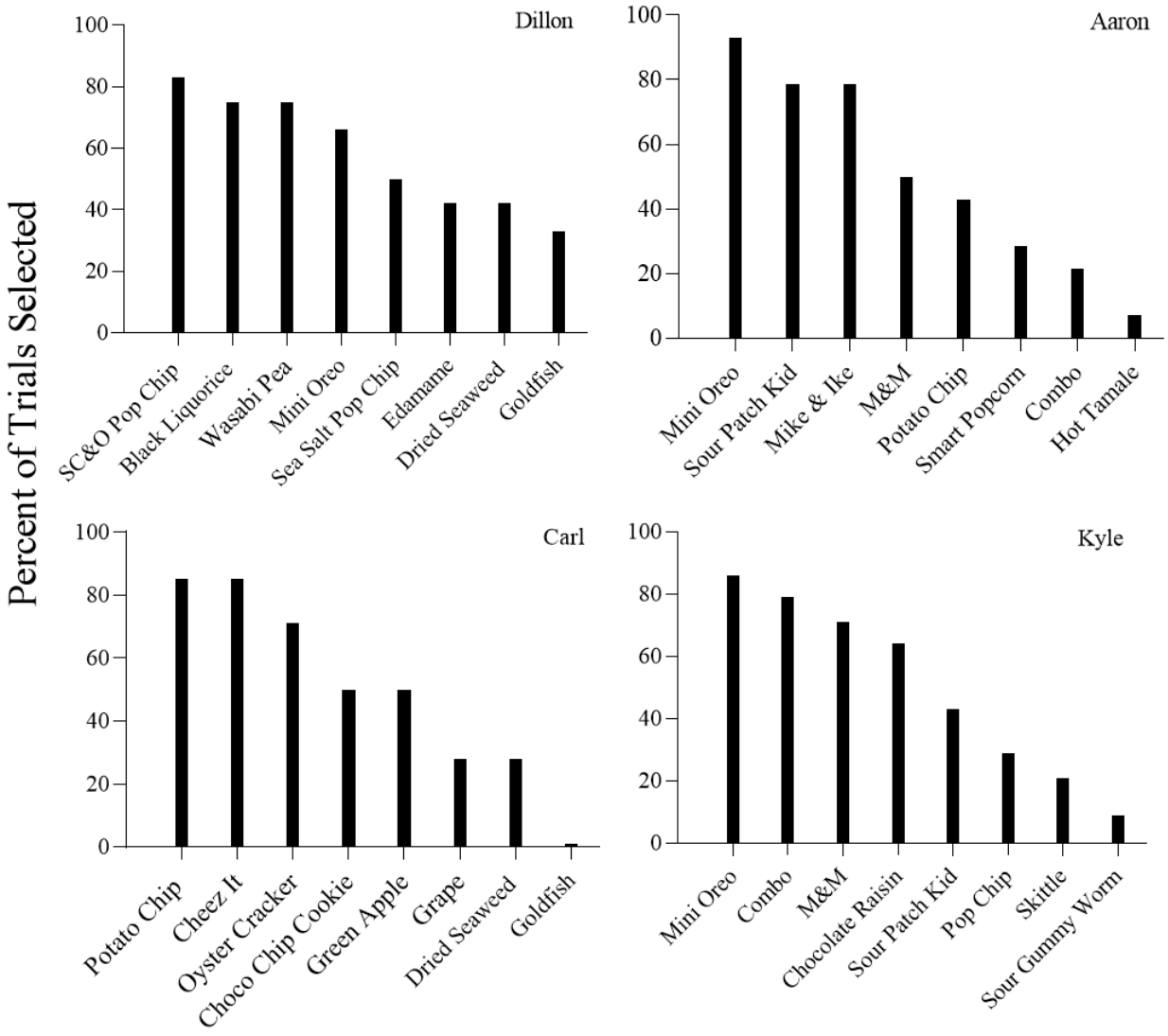
Figure 1

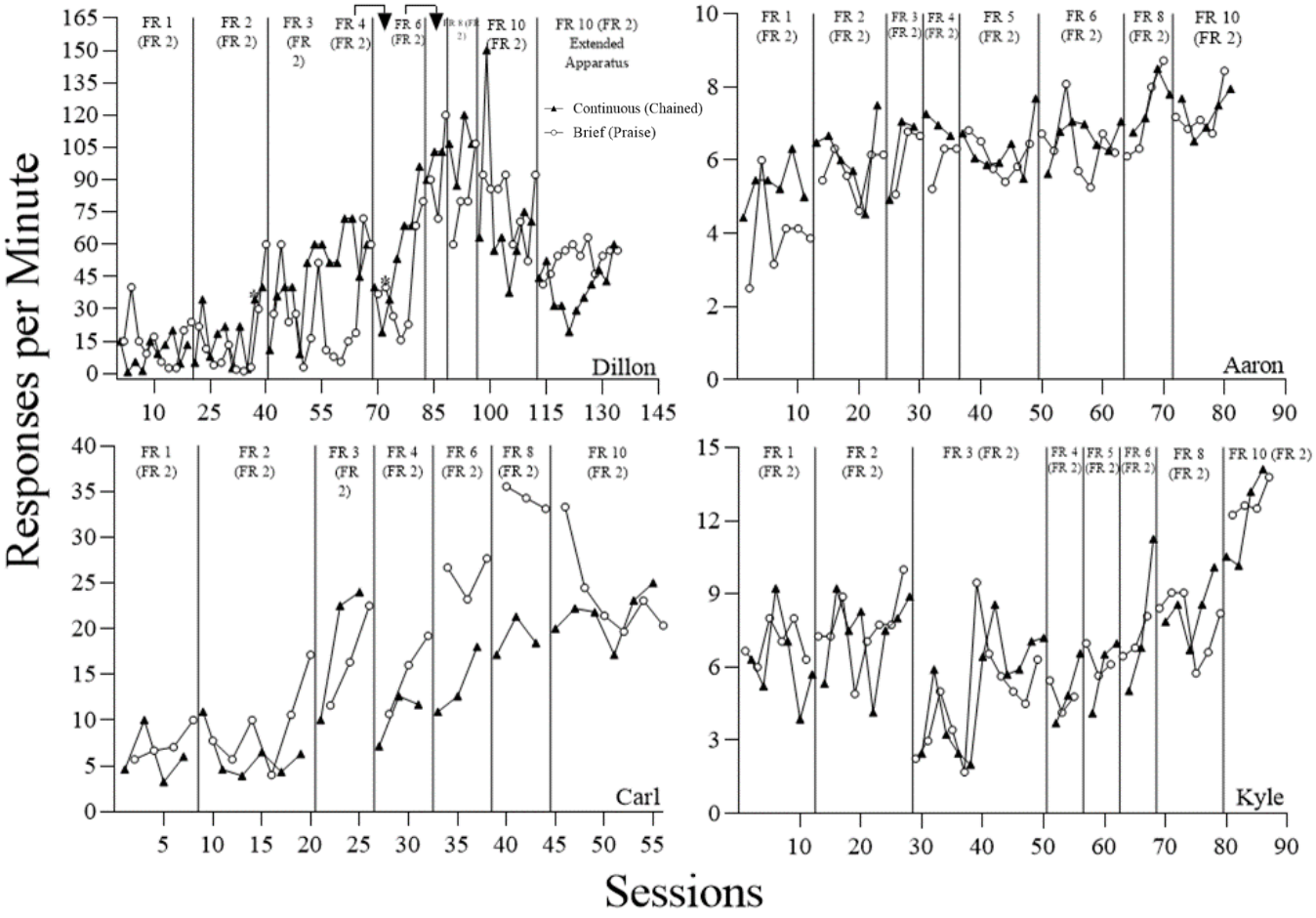
Paired Stimulus Preference Assessment



Note. Results of the PSPA for all participants. The percent of trials selected across each stimulus included in the assessment are shown for each participant

Figure 2

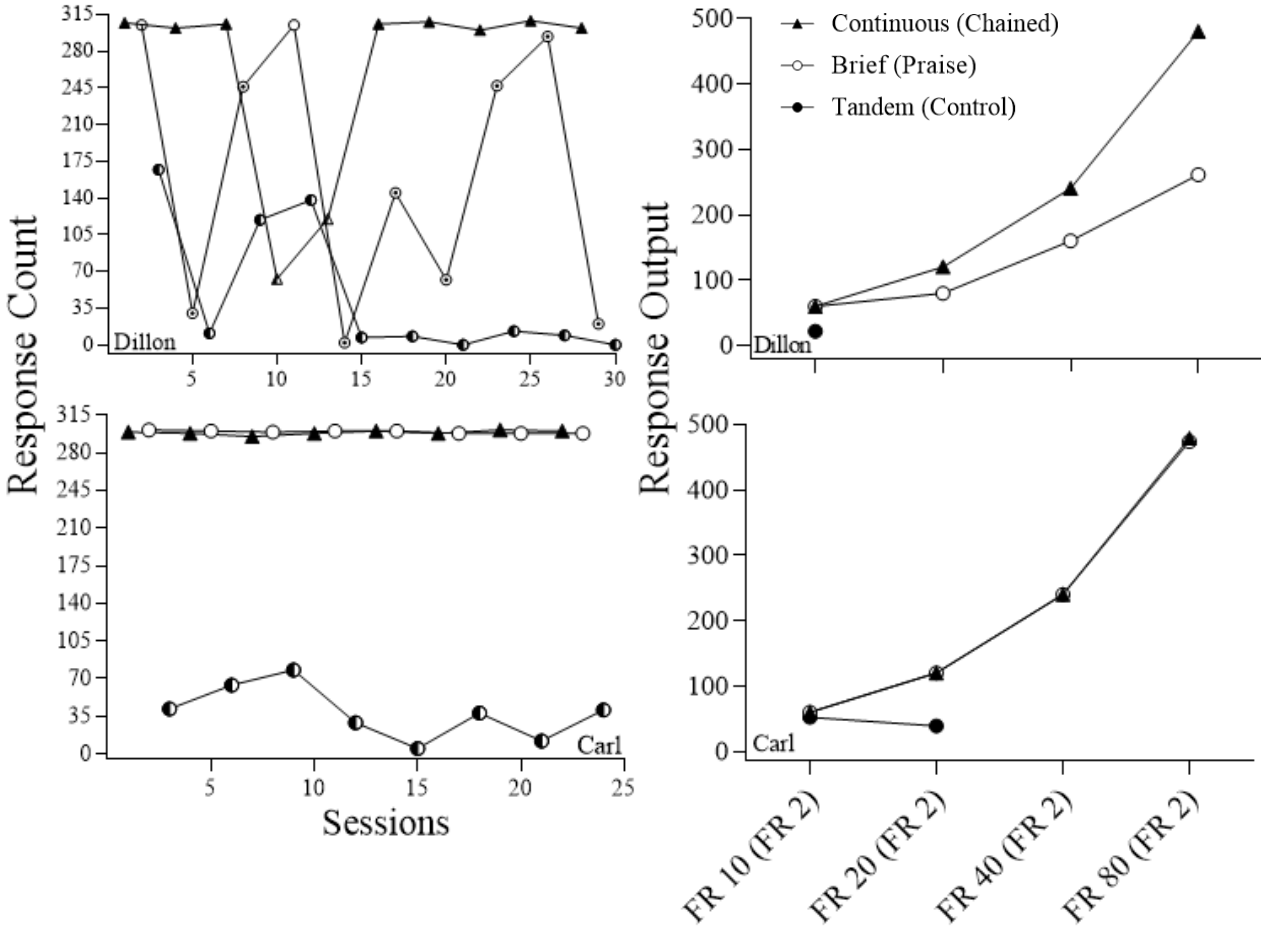
Second-order Schedule Thinning Response Rates



Note. Dillon's (top left panel) and Carl's (bottom left panel) response rates for the continuous (closed circles) and brief praise (open circles) conditions across each step of second-order scheduling thinning. The asterisks (*) above session 39 and 72 of the top panel indicate when the model prompt of the response prior to session start was initiated and terminated, respectively. The right panels display results of second-order schedule thinning for Aaron and Kyle, respectively.

Figure 3

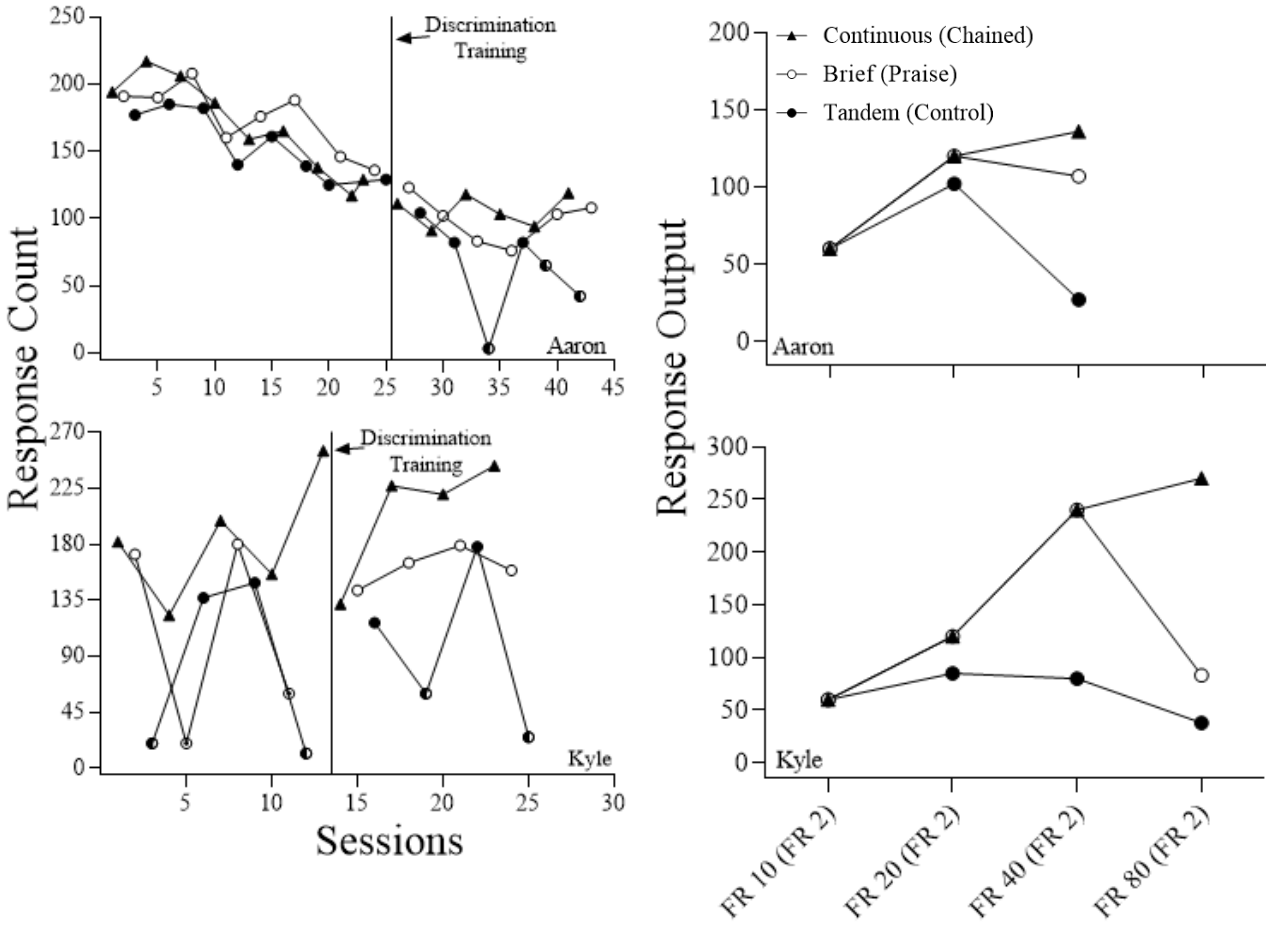
Progressive-ratio Response Counts and Outputs



Note. Response counts and outputs of PR analysis for Dillon (top left and right panels) and Carl (bottom left and right panel), respectively. The closed triangle, open circle, and closed circle data paths represent response counts and response outputs for the continuous, brief praise, and tandem conditions, respectively. In the response count graphs (left panels), the half-filled triangle, open circle with centered dot, and half-filled circle data markers indicate sessions for which the breakpoint criterion was met across continuous, brief, and tandem sessions, respectively. Response output figures were genereated from aggregated total response from each component schedule across the final three sesisons of the PR for each condition.

Figure 4

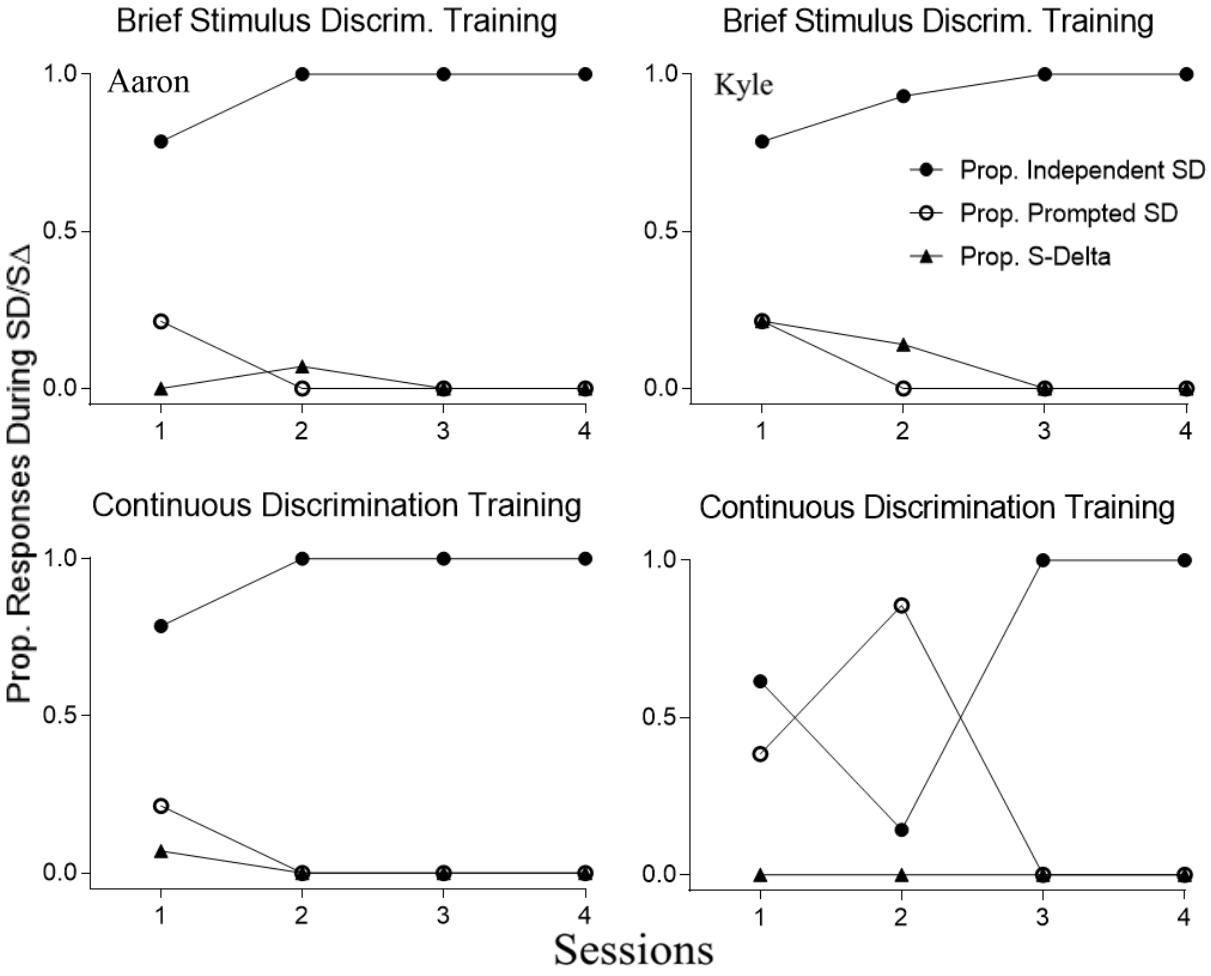
Progressive-ratio Response Counts and Response Outputs



Note. Response counts and outputs of PR analysis for Aaron (top left and right panels) and Kyle (bottom left and right panel), respectively. The closed triangle, open circle, and closed circle data paths represent response counts for the continuous, brief praise, and tandem conditions, respectively. In the left panels, the half-filled circles and open circles with dot denote sessions for which breakpoints were met during tandem and breif sessions, respectively. Response output figures were genereated from aggregated total response from each component schedule across the final three sesisons of the PR for each condition.

Figure 5

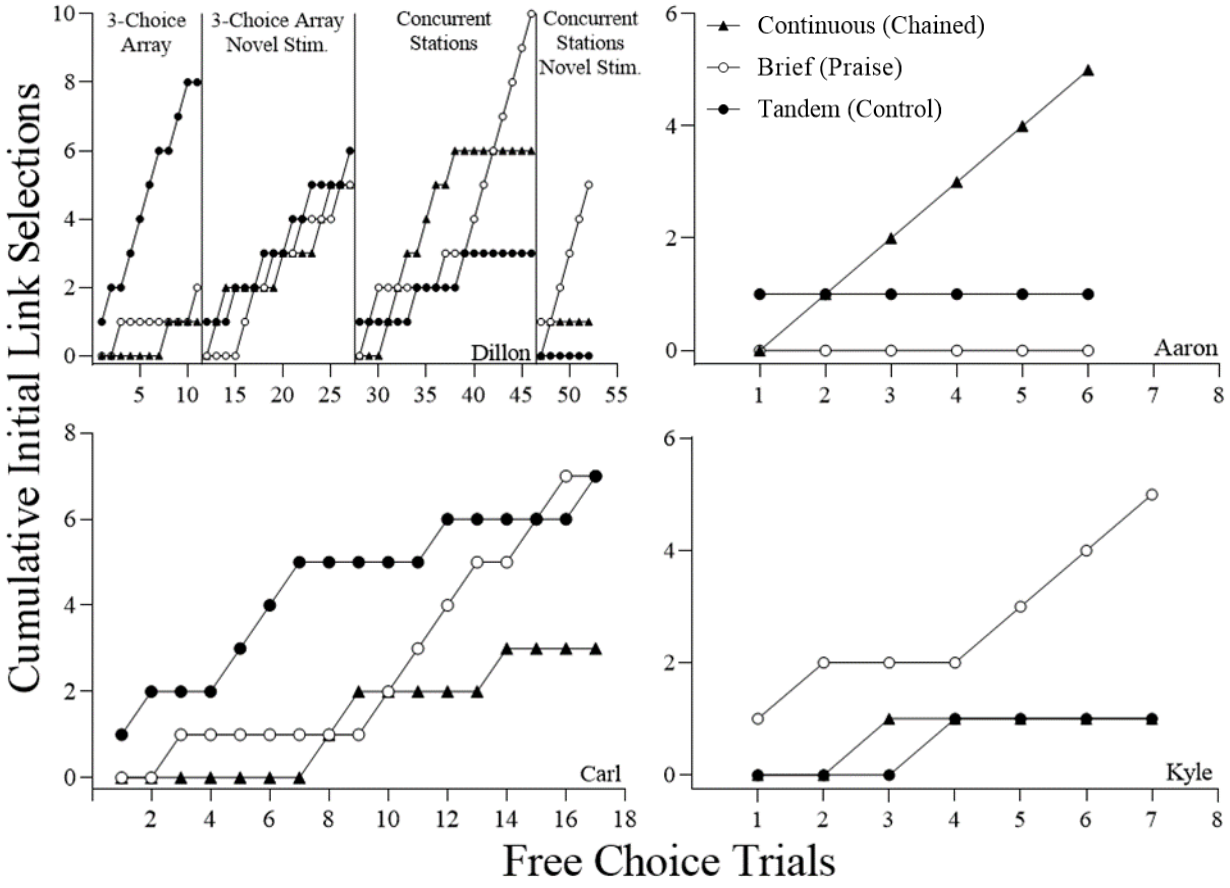
Responding across S^{Δ} and S^{D} Intervals During Discrimination Training



Note. Left and right panels show of discrimination training for Aaron ad Kyle, respectively. The upper and lower panels denote continuous and brief discrimination training sessions for each participant. The closed circle and open circle data paths represent proportion of independent and prompted consumption responses during across S^{D} intervals across sessions. The closed triangle data path shows proportion of consumption responses occurring during S^{Δ} intervals across sessions.

Figure 6

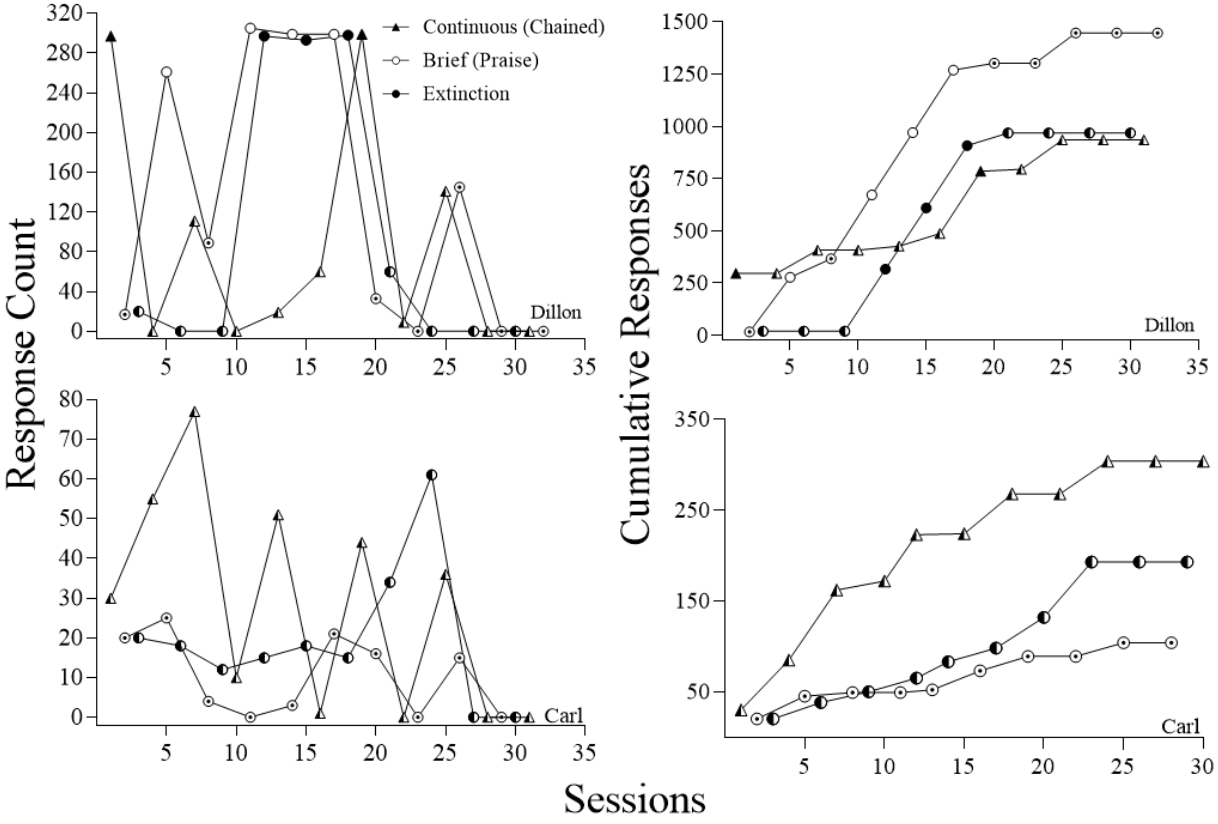
Initial Link Selection During Concurrent-chained Analysis



Note. Results of the concurrent-chained schedule choice analysis for Dillon (top left panel), Aaron (top right panel), Carl (bottom left panel), and Kyle (bottom right panel). Closed triangle, open circle, and closed circle data paths represent cumulative initial-link selections for the extended-chained, brief praise, and tandem second-order schedules, respectively, across free choice trials.

Figure 7

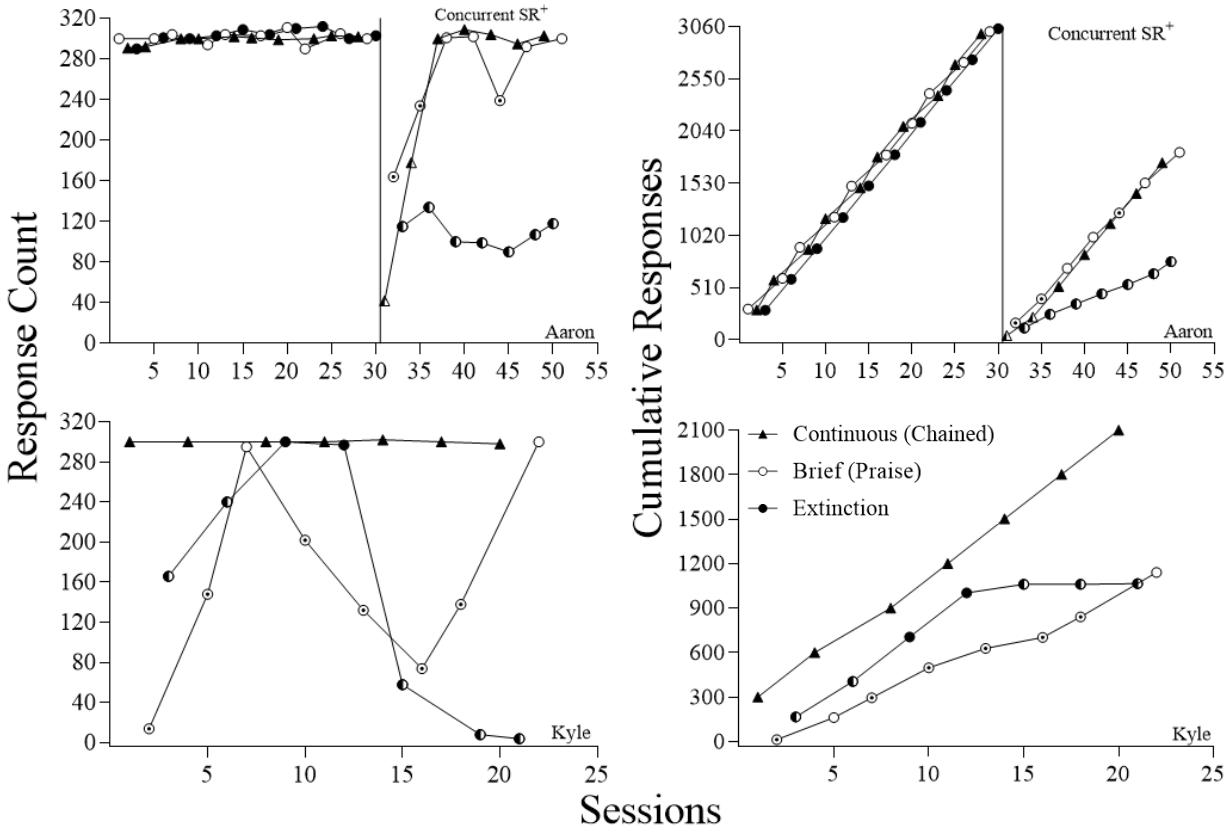
Response Count and Cumulative Records for Conditioned Reinforcer Durability Analysis



Note. Results of the conditioned reinforcer durability analysis for Dillon (top left and right panels) and Carl (bottom left and right panels). The closed triangle, open circle, and closed circle data paths represent response counts and cumulative responses for the continuous, praise, and extinction conditions, respectively. Sessions for which the breakpoint criterion was met during the continuous, brief, and extinction conditions are denoted by the half-filled triangle, open circle with dot, and half-filled circle, respectively.

Figure 8

Conditioned Reinforcer Durability Response Counts and Cumulative Records



Note. Results of the conditioned reinforcer durability analysis for Aaron (top left and right panels) and Kyle (bottom left and right panels). The closed triangle, open circle, and closed circle data paths represent response counts and cumulative responses for the continuous, brief praise, and extinction conditions, respectively. Sessions for which the breakpoint criterion was met during the continuous, brief, and extinction conditions are denoted by the half-filled triangle, open circle with dot, and half-filled circle, respectively.

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