Preference for Accumulated and Distributed Token Exchange-Production Schedules: Effects of Task Difficulty and Variable Token-Production Schedules

by

John Michael Falligant

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Approved by

Elizabeth Brestan-Knight, Chair, Professor of Psychology
Sacha Pence, Co-chair, Assistant Professor of Education
Christopher Correia, Professor of Psychology
Jan Newman, Clinical Assistant Professor of Psychology
Doris Hill, Assistant Research Professor of Education

Abstract

Organisms allocate behavior to simultaneously available schedules of reinforcement as a function of different dimensions of reinforcement (e.g., delays, magnitude, response effort). Previous research suggests that accumulated exchange-production schedules promote increased work completion and are more preferred than distributed exchange-production schedules despite the commensurate delays to reinforcement. The purpose of the present study was to evaluate whether the response effort or token-production schedules associated with token delivery influence preferences for exchange-production schedules. Tokens exchanged under accumulated schedules supported higher rates of responding and were more preferred, relative to distributed schedules, when they were earned for completing easy tasks (Experiment 1). When participants earned tokens for completing difficult tasks, they generally preferred accumulated exchange-production schedules, although accumulated schedules were not significantly more effective than distributed schedules in maintaining behavior (Experiment 2). Under dense token-production schedules, accumulated exchange-production schedules were preferred, but participant's preferences switched to distributed schedules under increasing token-production (i.e., leaner) schedules (Experiment 3).

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Introduction

Behavior-economic models of self-control evaluate choice behavior involving reinforcers as a function of contextual constraints, such as delays to reinforcement, magnitude of reinforcement, response effort, and schedules of reinforcement (e.g., Madden & Johnson, 2010). A plethora of behavior-economic research on impulsivity has focused on delay discounting, which describes how the value of an outcome is discounted (i.e., value decreases) as a function of time to its delivery (e.g., Madden & Johnson, 2010; Mazur, 1987). Within the delay-discounting framework, impulsivity is defined as preference for smaller, more immediate rewards relative to preference for larger, delayed outcomes (e.g., Odum, 2011). Steeper rates of delay discounting correspond to increased preference for immediate over delayed outcomes (e.g., Odum, 2011; Weatherly & Ferraro, 2011).

A variety of procedures, such as token-economy interventions, have been developed to increase organisms' self-control and preferences for delayed outcomes. Tokens are conditioned stimuli that can bridge temporal gaps between responses and delays to reinforcer delivery (DeFulio, Yankelevitz, Bullock, & Hackenberg, 2014; Reed & Martens, 2011). Importantly, tokens can help organisms discriminate between delays to reinforcement and situations in which reinforcement is unavailable (Williams, 1999). Tokens can establish preferences for larger, delayed outcomes relative to smaller, immediate outcomes (see Hackenberg, 2009). Three components of token-reinforcement procedures that may influence organisms' preference for, and the effectiveness of, token-reinforcement systems include token-production schedules, token-exchange schedules, and token exchange-production schedules. The token-production schedule specifies the number of responses required to earn a token. For example, under a fixed-ratio (FR) 10 token-production schedule, one token would be delivered following every 10 responses. The token-exchange schedule specifies the schedule by which tokens are exchanged for backup reinforcers (Hackenberg, 2009). The token-exchange schedule specifies how much the token is worth. An FR-1 token-exchange schedule, for example, would specify that each token is exchangeable for one unit of the backup reinforcer. The token exchange-production schedule specifies the number of tokens that must be earned before they can be exchanged for backup reinforcers (e.g., DeLeon et al., 2014; Hackenberg, 2009). For example, under an FR-10 exchange-production schedule, tokens cannot be exchanged for backup reinforcers until the organism has accumulated 10 tokens.

The arrangement of the specific values of the token-production, token-exchange, and token exchange-production schedules may directly influence organisms' preferences for concurrently available schedules of reinforcement. For example, previous research with non-human organisms indicates that, under schedules in which responding is reinforced with tokens, the number of responses required to enter the exchange period to access reinforcement disproportionately influences preferences for concurrently available schedules (Bullock & Hackenberg, 2006). Additionally, response rates tend to decrease as the magnitude of the token exchange-production schedules increase. In other words, the rate at which organisms respond to earn tokens decreases as the number of tokens required to enter the exchange period increases. There is also an inverse relation between token accumulation and token-production requirements, such that organisms accumulate fewer tokens as the number of responses required to earn a token (i.e., FR 1, FR 5, FR 10) increases (Yankelevitz, Bullock, & Hackenberg, 2008). Thus, organisms may exchange tokens more frequently under leaner token-production schedules relative to denser schedules.

Notably, the unit price associated with concurrently available schedules of reinforcement may also affect preference. Unit price is a behavior-economic term that refers to the number of reinforcers obtained per response (e.g., Foster & Hackenberg, 2004; Hursh, 1978; Madden et al., 2000; Roane, Falcomata, & Fisher, 2007). Unit price can be modified by changing the response requirement, the amount of the reinforcer, or both (Foster & Hackenberg, 2004). In an FR or variable-ratio (VR) schedule, the unit price of a reinforcer is determined by the ratio-schedule requirements (e.g., Madden et al., 2000; Tustin, 1994). Research on unit price among clinical populations has largely focused on preferences for concurrently available schedules of reinforcement across different unit price and schedule parameters. Tustin (1994) compared participants' choices to work for access to either visual (e.g., changing color patterns on a computer screen) or auditory (e.g., musical tones) reinforcers. Participants earned access to the visual stimuli on a FR 5 schedule and to the auditory stimuli on an increasing FR schedule (FR 1, FR 2, FR 5, FR 10, FR 20). Participants differentially allocated responding towards the schedule associated with auditory stimuli (relative to visual stimuli) when the unit price associated with the auditory stimuli was less than the unit price of the schedule associated with the visual stimuli (i.e., less than five). However, as the FR schedule for auditory stimuli increased beyond FR 5, preferences switched and responding was allocated towards the schedule associated with the visual stimuli. Thus, Tustin demonstrated that changes in the unit prices among concurrently available reinforcers can affect individuals' preferences for different reinforcement schedules and influence the degree to which responding is maintained.

Two schedule arrangements with different response requirements and reinforcer magnitudes can yield the same unit price if the response requirement to reinforcer magnitude ratio is held constant. For example, one schedule of reinforcement may program the delivery of three reinforcers following 30 responses whereas another schedule results in delivery of one reinforcer following 10 responses. Though the specific response requirements and reinforcer magnitudes differ across the two schedules, the unit price associated with both schedules is 10. Delmendo, Borrero, Beauchamp, and Francisco (2009) suggest that, so long as the unit price across two schedules is held constant, organisms tend to prefer the two schedules equally. However, extant research suggests this may not always be the case. That is, organisms' responding may vary across concurrently available schedules with equal unit-price ratios, but different response requirements. For example, Madden et al. (2000) evaluated respondents' preferences for concurrently available reinforcement schedules with equal unit price, but unequal cost-to-benefit ratios. When unit prices were relatively low, individuals preferred schedules with larger response requirement-reinforcer amount ratios. When unit prices were relatively high, individuals preferred schedules with smaller response requirement-reinforcer amount ratios. Thus, individuals may prefer schedules with larger response requirements and reinforcer magnitudes when overall costs are low, but their preferences may switch towards schedules with lower response requirements and reinforcer magnitudes as prices increase. This suggest that costs and benefits of different schedules with equal unit price may not be functionally equivalent under large and small unit prices. Said another way, people may prefer to complete more work to earn more reinforcers when the overall amount of work is relatively low. However, when the overall amount of work increases, people may prefer to complete less work and receive fewer reinforcers.

Apart from the aforementioned token schedule features, other contextual factors may influence organisms' preferences for schedules of reinforcement. For example, there are many dimensions of reinforcement, including immediacy or delay to reinforcement (e.g., Madden &

Johnson, 2010), that influence preference for and behavior allocation towards concurrently available schedules of reinforcement. The duration and quality of reinforcement (e.g., Beavers, Iwata, & Gregory, 2014; Hoch, McComas, Johnson, Faranda, & Guenther, 2002; Horner & Day, 1991; Neef, Bicard, & Endo, 2001; Neef et al., 2005) and the timing of delays to reinforcement (Leon, Borrero, & DeLeon, 2016) can also be manipulated to modify impulsive choice and increase preference for delayed or immediate schedules of reinforcement. Furthermore, the response effort (e.g., Lerman, Addison, & Kodak, 2006; Neef et al., 2005; Perrin & Neef, 2012) required to engage in behavior in concurrently available schedules of reinforcement (e.g., completing easy versus difficult tasks) may influence preference for concurrently available delayed and immediate reinforcement schedules. For example, when the response effort required to earn reinforcers are low (e.g., completing easy math problems), individuals will likely prefer immediate reinforcers over delayed reinforcers. However, if given the choice between immediate reinforcement for completing higher response-effort tasks (10 difficult math problems) or delayed reinforcement for low response-effort tasks (one easy math problem), individuals' preferences for delayed reinforcement may increase (e.g., Neef et al., 2005).

Another important parameter of reinforcement involves *continuity* of reinforcer access. For example, DeLeon et al. (2014) had participants with developmental disabilities (three adolescents and one young adult) earn tokens on an FR-1 schedule for completing easy tasks (e.g., folding towels) that were exchangeable for access to preferred leisure activities (e.g., playing Legos), with each token worth 30-s access to the leisure item. Under distributed exchange-production schedules, participants earned immediate 30-s access to a preferred leisure activity following compliance with an easy demand. During accumulated exchange-production schedules, participants entered into an exchange period once they had aggregated 10 tokens (i.e., one token was delivered following each instance of compliance). Although the accumulated exchange-production schedules were associated with delays to reinforcement, accumulated schedules supported higher rates of work completion than distributed schedules. Additionally, participants preferred to work under accumulated schedules despite the associated delays to reinforcement. These findings are consistent with other research suggesting accumulated exchange-production schedules are more efficient and facilitate greater rate of work completion (Bukala, Hu, Lee, Ward-Horner, & Fienup, 2015; Ward-Horner, Cengher, Ross, & Fienup, 2017), and are also more preferred relative to distributed exchange-production schedules (e.g., Fienup, Ahlers, & Pace, 2011; Kocher, Howard, & Fienup, 2015).

Within the current literature, it is unknown how preferences for exchange-production schedules may be influenced by the response effort and unit price associated with concurrently available schedules of reinforcement. However, extant research (e.g., Lerman et al., 2006; Neef et al., 2005; Perrin & Neef, 2012) suggests that changes in task difficulty may affect individuals' preferences for delayed versus immediate schedules of reinforcement, indicating that accumulated exchange-production schedules may not be as preferred or effective when associated with more effortful work requirements (Ward-Horner et al., 2017). Nonetheless, there is little research to date that has examined differences in preferences for, and the effectiveness of, accumulated and distributed exchange-production schedules across easy and difficult tasks. This is notable given that token economies are often used to increase responding when tasks or behaviors are effortful or aversive (e.g., McLaughlin, Williams, & Howard, 1998). For example, a token economy might be implemented to increase compliance with aversive academic tasks with an individual with escape-maintained problem behavior. Accordingly, the purpose of the present study was to replicate and extend research by DeLeon et al. (2014) by evaluating the effectiveness of, and participants' preferences for, accumulated and distributed exchange-production schedules under easy (Experiment 1) and difficult (Experiment 2) work requirements. Furthermore, participants' preferences for accumulated and distributed schedules were evaluated under different (e.g., FR 1, VR 2, VR 5, VR 10) token-production schedules to evaluate the effects of changes in unit price on schedule preferences (Experiment 3).

General Method

Participants and Setting

Three children participated in all three experiments. Sam was an eight-year-old male diagnosed with high-functioning autism spectrum disorder (ASD) and attention-deficit/hyperactivity disorder (ADHD). Dan was a 10-year-old male diagnosed with ADHD. Ricky was a 10-year-old male diagnosed with high-functioning ASD. Participants communicated vocally using full sentences of five or more words and were able to follow multi-step directions. All participants' academic abilities were generally consistent with their grade level, demonstrating grade-appropriate literacy (e.g., five-letter spelling) and numeracy (e.g., addition, multiplication) skills. All participants had a history of challenging behavior ranging from mild (e.g., crying, arguing) to severe (e.g., head-directed aggression, biting) topographies of problem behavior. As part of ongoing clinical services for all participants, prior functional analyses (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994) had been conducted and identified that all participants engaged in escape-maintained problem behavior. All participants had prior experience with token economies in clinical (Dan and Ricky) or academic/clinical (Sam) settings where tokens were earned for completing academic work (e.g., math problems) and compliance with adult directives and had resulted in increases in compliance, suggesting that the tokens served as conditioned reinforcers. All participants would independently initiate token exchanges and exchange their tokens for edible and activity reinforcers. In their prior token-reinforcement programs, the number of tokens required for exchange differed for each participant; however, each participant had an individualized menu with backup reinforcers at individualized token-exchange values.

Sessions were conducted in a clinic room on a university campus. The clinic room (10 m by 15 m) included two child-sized tables and several chairs. Participants attended two to three appointments per week for three to six months, depending on the participant's progress. Each appointment lasted no longer than two hours and included multiple sessions. The participants and therapist used a variety of manipulative activities and toys (e.g., action figures, interactive toys, iPads, matchbox cars), and edibles (e.g., crackers, fruity candy, chocolate) during each session. A laminated sheet of paper and erasable marker were used as a token board.

Undergraduate and graduate trainees were trained as secondary observers to independently collect data. Interobserver agreement (IOA) was calculated on an interval-by-interval basis for the reinforcer assessments and concurrent-operant preference assessments, or on a trial-by-trial basis for modified concurrent-chains preference assessments. An agreement was defined as both observers recording the same response during each interval or trial. Interobserver agreement was calculated by dividing the number of agreements by the number of agreements plus disagreements then converting this fraction to a percentage by multiplying by 100. In Experiment 1, IOA was collected across 51% of sessions, with a mean interobserver agreement of 90% (range, 62%-100%). In Experiment 2, IOA was collected across 47% of sessions, with a mean interobserver agreement of 91% (range, 67%-100%). In Experiment 3, IOA was collected across 24% of sessions, with mean interobserver agreement of 99% (range, 67%-100%).

Pre-Experimental Procedures

Preference assessment. A multiple-stimulus without-replacement (MSWO; DeLeon & Iwata, 1996) preference assessment was used to identify highly preferred stimuli to be used as backup reinforcers. Separate MSWO preference assessments were conducted for edibles and tangibles. Highly preferred stimuli used in the current study included access to iPads (Dan and Ricky) and Legos (Sam), chips and cheese crackers (Dan and Ricky), and chocolate, sour gummies, and fruit candy (Sam).

Token training. A token-training procedure similar to that described by DeLeon et al. (2014) was used to train participants to independently exchange tokens for backup reinforcers and to ensure all participants had the same history with tokens immediately before beginning Experiment 1. Sessions consisted of 10 trials, with each trial including an opportunity for the participant to trade-in his tokens. Independent token trading was defined as the participant handing the token board with the correct number of tokens to the therapist within 10 s of the therapist placing his or her hand palm facing upwards in front of the participant. Participants earned tokens (i.e., tally marks on laminated paper) on a FR-1 schedule for complying (independently or following the model prompt) with easy tasks within their current skill repertoire (e.g., addition, subtraction, spelling, motor imitation, receptive identification, matching). They exchanged the tokens according to an FR-1 token-exchange schedule for backup reinforcers (one token was exchanged for one small edible or 30-s access to a tangible) when the exchange-production requirement was met. The next trial began immediately at the conclusion of the previous trial (i.e., following consumption of the backup reinforcers) and started when the therapist delivered an easy directive for the participants to complete. The number of tokens required to exchange increased across three steps. At Step 1, one token was required to enter the exchange period. At Step 2, five tokens were required to enter the exchange period. At Step 3, 10 tokens were required to enter the exchange period. The criteria to increase a step was two consecutive sessions with 90% or greater correct independent token trading across trials. The independent token training mastery criterion was defined as two consecutive sessions with 90% correct independent token trading across trials at Step 3.

Demand assessment. A demand assessment was used to identify a minimum of two easy and two difficult tasks for each participant. The therapist evaluated several academic demands, including one-letter, two-letter, three-letter, four-letter, and five-letter spelling problems, and single- and double-digit addition, subtraction, and multiplication mathematics problems. Each session consisted of 10 trials. All trials within a session consisted of demands of the same type (e.g., all single-digit multiplication problems). Two sessions were conducted for each type of demand. Sessions with each type of demand (e.g., single-digit addition, double-digit multiplication) were presented quasi-randomly, and demands of the same type were not presented across two consecutive sessions. There was a 3-min intersession interval between each session, during which participants could to talk the therapist or engage with leisure activities.

At the onset of each trial, the therapist delivered a demand (e.g., "Spell 'hotel'"). If the participant complied with the demand within 30 s, the therapist delivered brief, neutral nondescriptive praise (e.g., "good"). If the participant did not comply within 30 s or engaged in problem behavior, the therapist refrained from commenting, scored the trial as noncompliance, and then ended the trial. If the participant initiated the task, but answered incorrectly, the therapist provided a vocal-model prompt (i.e., a vocal description of the steps for obtaining the correct answer). If the participant answered correctly following the prompt, the therapist provided praise and scored the response as compliance. If the participant answered incorrectly following the prompt, the therapist scored the response as noncompliance and immediately delivered the next academic demand. Easy demands were defined as demands with at least 80% of trials with compliance across two sessions. Difficult demands were defined as demands with 50% or fewer trials with compliance across two sessions. See Table 1 for a list of the identified easy and difficult demands for each participant.

Experiment 1

Response Measurement

Paper-and-pencil data collection was used to record the frequency of the dependent variables within sessions (reinforcer assessment) or trials (modified concurrent-chains preference assessment). Frequency data for compliance, aggression, and property destruction were recorded and converted to rate for each session. *Compliance* was defined as any instance of the participant initiating a task (i.e., putting pencil to paper) within 10 s of the initial demand and completing the task within 30 s of the initial demand in the absence of aggression and property destruction. Compliance did not include any instance in which the participant engaged in aggression or property destruction after the demand was delivered. *Aggression* was defined as any instance of the participant kicking, head butting, or hitting another person with an open or closed hand or object from at least 10 cm, any instance of biting (or attempted biting), hair pulling, pinching, or pushing another person, or any instance of throwing an object that made contact with another person. Aggression did not include high fiving or tapping on the shoulder or arm. *Property destruction* was defined as any instance of the participant throwing (without making contact with another person) an object at least 0.5 m, dumping (emptying a container onto a surface from at least 0.3 m, stomping, breaking, kicking, hitting, tearing, or punching an object or wall from at least 15 cm, or swiping objects with one or both hands or feet. Property destruction did not include breaking apart Legos or Kinex.

Reinforcer Assessment: Easy Tasks

The effectiveness of the token-reinforcement procedures with accumulated and distributed token exchange-production schedules on work compliance with easy tasks (see Table 1) was evaluated using a within-subject ABAB reversal with embedded multielement design. The therapist rotated between easy tasks in a quasi-random manner so that every type of easy academic demand (e.g., two-letter spelling, two-letter addition) was presented at least once per session. All sessions ended after either 5 min or once the participant complied with 10 directives (whichever occurred first). The session time was paused during token-exchange periods while the participants consumed backup reinforcers. If participants complied with 10 directives before the 5-min session ended, the session time consisted of the duration from the onset of the session until the token trade following the tenth demand. Each condition was signaled by delivering a vocal instruction and placing a laminated sheet of paper (21 cm x 28 cm) associated with each condition approximately 1 m high on the wall of the clinic room.

Baseline. The baseline condition was signaled by a picture of an “X” on the wall. The token board was placed in front of the participant. Prior to the start of each session, the therapist stated, “It’s time to do some work. You can do these problems if you want to” and delivered a demand. The session began immediately before delivering the first demand. If the participant completed the correct response within 30 s of the initial demand, compliance was scored. Following compliance, the therapist delivered brief, nondescriptive neutral praise (e.g., “good”) and presented the next demand. If the participant did not initiate a response within 10 s of the demand (i.e., noncompliance) or engaged in aggression or property destruction, the therapist immediately delivered a new demand. If the participant initiated a response within 10 s of the demand, but answered incorrectly, the therapist provided a vocal prompt (i.e., stated the correct answer; e.g., "Chair is spelled C-H-A-I-R"). If the participant answered incorrectly following the prompt, the therapist provided a vocal prompt (stated the correct answer) and physically guided the correct response, scored the response as noncompliance, and delivered the next directive.

Distributed. The distributed condition was signaled by a picture of a single coin on the wall. The token board was placed in front of the participant. Prior to the start of each session, the therapist stated, "It's time to do some work. You can do these problems if you want to. When you complete a problem, you will get one tally right away [gestures to token board] to trade for 30 s of [preferred activity] or one small piece of snack" and delivered a demand. If the participant complied within 30 s of the initial directive (independently or with the vocal prompt), the therapist delivered nondescriptive neutral praise (e.g., "good"), and a token by saying "you earned a token" and drawing a tally on the participant's token board and scored compliance. Following noncompliance, aggression, or property destruction, the therapist delivered a new academic demand. If the participant initiated the academic demand, but provided an incorrect answer, the therapist delivered a vocal prompt. Following compliance, the therapist delivered nondescriptive neutral praise and one token (i.e., one tally on the token board). If the participant answered incorrectly following the vocal prompt, the therapist provided a vocal prompt and physically guided the correct response, scored the response as noncompliance, and delivered the next demand. As soon as the response requirement was met (1 token), the therapist extended his/her hand. When the participant placed the token board in the therapist's hand, the therapist paused the session timer and provided 30-s access to a preferred item or one small edible that the participant selected during the exchange period. The timer resumed once the therapist delivered a new demand following the reinforcement interval.

Accumulated. The accumulated condition was signaled by a picture of a stack of coins on the wall. The token board was placed in front of the participant. Prior to the start of each session, the therapist stated, "It's time to do some work. You can do these problems if you want to. When you complete a problem, you will get one tally [gestures to token board] that's worth 30 s of [preferred activity] or one small piece of snack. You can trade all of your tokens in after you have finished working" and delivered a demand. Following compliance (independently or after the vocal model) within 30 s of the demand, the therapist delivered nondescriptive neutral praise and one token by saying "you earned a token" and drawing a tally on the participant's token board. Following noncompliance, aggression, or property destruction, the therapist delivered a new academic demand. If the participant initiated the academic demand, but answered incorrectly, the therapist provided a vocal prompt. If the participant complied with the vocal model, the therapist delivered neutral nondescriptive praise and one token. If the participant answered incorrectly following the vocal prompt, the therapist provided a vocal prompt and physically guided the response, scored the response as noncompliance, and delivered the next demand. After the participant complied with 10 academic demands or after 5 min elapsed, the participant could exchange his accrued tokens. As soon as the response requirement was met (10 tokens), the therapist extended his or her hand. Each token worth 30-s access to his preferred activity or one small piece of edible. The session timer stopped once the participant placed the token board in the therapist's hand.

Modified Concurrent-Chains Preference Assessment

Preference for accumulated and distributed exchange-production schedules with easy tasks was evaluated using a modified concurrent-chains preference assessment (e.g., DeLeon et al., 2014). The therapist presented easy academic demands similar to those used in the reinforcer assessment. Prior to beginning the assessment, the therapist conducted two forced-choice trials for each condition (i.e., control, distributed, accumulated). Before the start of the forced-choice trials, the therapist stated, "It's time to do some work. Each of these sheets [pointing to laminated sheets associated with each condition] shows a different way to earn tallies. This sheet [point to control] means that you do work, but don't earn tallies. This sheet [point to distributed] means that you earn one tally at a time. This sheet [point to accumulated] means that you can trade-in all of your tallies once you have earned 10 tallies. We're going to test them out. Select the _____ card." During the forced-choice selection of each card, the therapist began the corresponding condition and implemented the condition as described in the reinforcer assessment. Following the forced-choice trials, the therapist began the concurrent-chains preference assessment.

At the beginning of each choice trial during the concurrent-chains preference assessment, the therapist stated, "It's time to do some work. Which way would you like to work and earn tallies?" All three cards were placed in front of the participant. If the participant vocally stated his selection or touched the card, the therapist recorded his response and conducted the selected condition as described in the reinforcer assessment. If the participant did not state his selection or touch the card within 10 s, or selected multiple schedules, the therapist prompted him to "pick one" while holding up the three cards in front of him. If no choice occurred, the therapist removed the cards for 30 s and then re-presented the cards. A minimum of 10 choice trials were conducted.

Results and Discussion

Rates of compliance are displayed in Figure 1 for Sam (top panel), Dan (middle panel), and Ricky (bottom panel) across baseline and reinforcer assessment sessions. Sam initially displayed moderate, stable rates of compliance during reinforcer assessment sessions with both accumulated (*M* = 4.7) and distributed (*M* = 3.4) token exchange-production arrangements. During baseline, Sam's rate of compliance decreased to low levels (*M* = 1.3). He engaged in higher rates of compliance on the following accumulated (*M* = 7.8) exchange-production schedules relative to distributed (*M* = 5.3) schedules. Rates of responding remained decreased during the return to baseline (*M* = 0.6). Rates increased during the final reinforcer assessment phase and were higher in the accumulated (*M* = 12.3) compared to distributed (*M* = 7.3) condition.

Dan's rate of responding was relatively high during initial baseline sessions (*M* = 3.9), and rates remained high across subsequent accumulated (*M* = 3.8) relative to the distributed (*M* = 2.5) condition during the reinforcer assessment. Dan's response rate remained high (*M* = 4.3) during the return to baseline. Responding maintained at similar levels during the reinforcer assessment and was differentially higher in the accumulated (*M* = 4.5) condition relative to distributed (*M* = 3.8) condition.

Ricky's response rates were relatively high during initial baseline sessions (*M* = 4.2). During the reinforcer assessment, he responded at differentially higher rates during the distributed exchange-production condition (*M* = 4.7) relative to the accumulated (*M* = 4.3) conditions. Ricky responded at similar rates during the return to baseline (*M* = 4.2) and subsequent distributed (*M* = 5.2) and accumulated (*M* = 4.3) conditions Thus, for two of the three participants (Dan and Sam), response rates were differentially higher during accumulated reinforcer assessment conditions compared to distributed conditions.

Across participants, the mean rate of work completion was lower during baseline (*M* = 3.4; *SD* = 1.9) than during distributed (*M* = 4.4; *SD* = 1.5) and accumulated (*M* = 5.4; *SD* = 2.7) conditions. Kruskal-Wallis one-way analyses of variance tests with Dunn's nonparametric post-hoc tests were used to evaluate differences in response rates across conditions. There was a significant difference in response rates across conditions (Kruskal-Wallis; $\chi^2 = 8.66$, $df = 2$, $p = .013$), as response rates were significantly higher during accumulated conditions relative to baseline ($p = .011$). There was no significant difference between response rates in baseline and distributed conditions ($p = .18$) or accumulated and distributed conditions ($p = .83$).

Participants' cumulative selections for accumulated and distributed exchange-production schedules during the modified concurrent-chains preference assessment are displayed in Figure 2 for Sam (top panel), Dan (middle panel), and Ricky (bottom panel). Sam, Dan, and Ricky all selected the accumulated exchange-production schedule on 9 of 10 (Sam), 10 of 10 (Dan), and 8 of 8 (Ricky) sessions, indicating a preference for accumulated exchange-production schedules.

Consistent with extant research involving token exchange-production schedules (e.g., Ward-Horner et al., 2017), tokens exchanged according to accumulated exchange-production schedules supported higher rates of behavior compared to tokens exchanged under distributed exchange-production schedules for two of three participants. Notably, DeLeon et al. (2014) did not deliver tokens during the distributed exchange-production schedule, instead allowing immediate access to the backup reinforcer. Results from the current experiment suggest the increased effectiveness of, and preference for, tokens exchanged under accumulated schedules compared to distributed schedules is not simply accounted for by the absence of conditioned stimuli during the distributed exchange-production schedules in DeLeon et al. Rather, accumulated exchange-production schedules likely support higher rates of responding, and are more preferred, relative to distributed schedules regardless of the presentation of conditioned stimuli under distributed schedule arrangements.

The high levels of responding observed during baseline with Dan and Ricky are a limitation, making it difficult to evaluate the reinforcing value of tokens earned in both accumulated and distributed arrangements. The relatively high levels of compliance that persisted in the absence of programmed reinforcer delivery may be due to use of easy tasks, and the relatively brief (i.e., 10 instances of compliance or 5 min) sessions. In addition, participants' learning histories with token reinforcement may have led to persistence during baseline conditions even though no tokens were delivered. Overall, participants readily complied with academic directives across brief sessions, resulting in high rates of compliance. Thus, it may be difficult to make comparisons between response rates during baseline in the current experiment and performance during baseline sessions associated with more difficult tasks or longer sessions.

It is unknown how the relative efficacy and preference of accumulated schedules is affected by increased response requirements, as task difficulty and response effort may moderate self-controlled responding and preferences for delayed outcomes (e.g., Lerman et al., 2006; Neef et al., 2005; Perrin & Neef, 2012). Accordingly, the purpose of Experiment 2 was to evaluate how increases in task difficulty affects participant's preference for, and the effectiveness of, accumulated and distributed exchange-production schedules within token-reinforcement contexts.

Experiment 2

Response Measurement

The same dependent variables and data collection procedures were used as described in Experiment 1.

Reinforcer Assessment: Difficult Tasks

The therapist delivered a minimum of two different types of difficult academic tasks (as identified by the pre-experimental demand assessment; see Table 1) using the same procedures as described in Experiment 1.

Modified Concurrent-Chains Preference Assessment

The therapist delivered difficult academic tasks using the same procedures as described in Experiment 1.

Results and Discussion

Rates of compliance are displayed in Figure 3 for Sam (top panel), Dan (middle panel), and Ricky (bottom panel) across baseline and reinforcer assessment sessions. During initial baseline sessions, Sam's rates of responding were low (*M* = 0.7). His response rates increased under both accumulated (*M* = 5.1) and distributed (*M* = 3.9) exchange-production schedules. Response rates decreased to zero levels during the return to baseline. During the second reinforcer assessment phase, responding increased to high levels in the accumulated (*M* = 4.3) and distributed (*M* = 4.3) conditions.

Dan engaged in moderate rates of responding during the initial baseline condition (*M* = 2.3). Rates of compliance were more variable during the reinforcer assessment phase and were higher in the accumulated (*M* = 2.7) than distributed (*M* = 1.9) conditions. Response rates remained moderate during the subsequent return to baseline (*M* = 2.8) and persisted at similar levels in the accumulated (*M* = 2.5) and distributed (*M* = 2.8) conditions.

Ricky engaged in low response rates during initial baseline sessions (*M* = 0.7). Rates of responding remained at similar levels in the distributed (*M* = 0.6) condition and increased under the accumulated (*M* = 1.0) condition. Response rate increased during the subsequent return to baseline (*M* = 1.6). Response rates were more variable, but increased during the final accumulated (*M* = 1.6) and distributed (*M* = 1.8) conditions.

For two of the three participants (Sam and Ricky), response rates were differentially higher during accumulated reinforcer assessment conditions compared to distributed conditions. Consistent with Experiment 1, the mean rate of work completion across participants was lower during baseline (*M* = 1.5; *SD* = 1.0) than during distributed (*M* = 2.7; *SD* = 1.5) and accumulated (*M* = 3.22; *SD* = 1.8) conditions. Similar to Experiment 1, there was a significant difference in response rates across conditions (Kruskal-Wallis; $\chi^2 = 19.16$, $df = 2$, $p < .001$), as response rates were significantly higher during accumulated conditions relative to baseline ($p < .001$) and also higher during distributed conditions relative to baseline ($p = .003$). Notably though, there was no statistically significant difference in response rates between accumulated and distributed conditions ($p = .60$).

Figure 4 depicts mean response rate, aggregated across all participants, by easy and hard tasks. When comparing response rates between easy and hard tasks across schedules, response rates were significantly higher for participants completing easy tasks (*M* = 4.89; *SD* = 2.21) compared to hard tasks (*M* = 2.97; *SD* = 1.65). This difference was statistically significant (Kruskal-Wallis; $\chi^2 = 42.38$, $df = 1$, $p = <.001$) and suggests the demand assessment effectively identified easy and hard tasks.

Participants' cumulative selections for accumulated and distributed exchange-production schedules during the modified concurrent-chains preference assessment are displayed in Figure 5 for Sam (top panel), Dan (middle panel), and Ricky (bottom panel). Sam and Dan primarily selected the accumulated schedule, indicating a preference for the accumulated exchange-production schedules. Ricky initially altered his selections between the accumulated and distributed schedules and then selected the distributed schedule across the last three choice opportunities, selecting distributed schedules for a total of 7 of 11 sessions. This pattern of responding suggests a preference for distributed exchange-production schedules.

When completing hard tasks, tokens exchanged according to accumulated exchange-production schedules generally supported higher (but not statistically significant) rates of behavior relative to distributed exchange-production schedules. In contrast, when completing easy tasks, accumulated exchange-production schedules consistently supported significantly higher rates of behavior for two participants (Sam and Dan). Taken together, these results suggest accumulated exchange-production schedules are likely more effective compared to distributed schedules in token-reinforcement contexts with both easy and hard tasks, although the effectiveness of the accumulated schedules appears to be pronounced when participants earn tokens for completing easy (as opposed to hard) tasks. Two of three participants (Sam and Dan) continued to prefer accumulated schedule arrangements relative to distributed schedules when completing hard tasks. One participant's preferences (Ricky) switched from accumulated schedules (Experiment 1) to distributed schedules (Experiment 2) when task difficulty increased. Accordingly, task difficulty may influence individuals' preferences for accumulated or distributed exchange-production schedules.

Future research should evaluate how increases in session duration or response requirements affect compliance during reinforcer and preference assessments. Similar to DeLeon et al. (2014), session time in Experiments 1 and 2 was capped at 5 min (assuming participants did not complete all 10 academic directives before the end of session). Extending the session duration or increasing the response requirements needed to end each session (e.g., 30 instances of compliance) may alter the efficacy of and participants' preferences for accumulated and distributed exchange-production schedules. Self-generated rules (“This work session will end soon”) or prior learning histories with token-reinforcement programs may promote responding during reinforcer assessment conditions with either no programmed contingencies or extremely delayed contingencies (Leon et al., 2016). Thus, the relatively brief sessions and participants’ prior experience with token-reinforcement programs may have contributed to response persistence during baseline reinforcer assessment conditions, particularly for Dan and Ricky.

Considering that token-reinforcement programs are likely to be used in treatment contexts (e.g., classroom settings) associated with high-effort tasks (e.g., difficult academic material or adult directives), future research should evaluate the generality of extant token exchange-production schedule research (see Ward-Horner et al., 2017) to applied contexts with increased response requirements. Indeed, token-reinforcement interventions in applied settings often use fairly lean token-production schedules (e.g., Tarbox et al., 2006). Contemporary research suggests changes in the token unit price and the number of responses required to enter the token-exchange period may affect preferences for delayed reinforcement (Madden et al., 2000). Little research has evaluated how preferences for different token exchange-production arrangements are affected by changes in work-reinforcer ratios even though token-thinning procedures are frequently necessary components of token-reinforcement programs (e.g., Parry-Cruwys et al., 2011). Indeed, research evaluating parameters of accumulated and distributed token exchange-production schedules typically use continuous token-production schedules (e.g., DeLeon et al., 2014). It is plausible that accumulated exchange-production schedules may be preferred under dense (e.g., FR 1) schedules of reinforcement, but be less preferred under leaner (e.g., VR 5) schedules. Individuals’ preferences may switch towards more-immediate (i.e., distributed) concurrently available schedules as a function of increasing token unit prices (i.e., increases in token-production schedules; Borrero, Francisco, Haberlin, Ross, & Sran, 2007; Tustin, 1994).

Although an FR 1 token-production schedule was used in Experiments 1 and 2 to assess participants' preferences for accumulated and distributed exchange-production schedules, individuals' preferences for the accumulated and distributed schedules may be influenced by changes in the token-production schedule, in which more responses are required to earn tokens. Accordingly, the purpose of Experiment 3 was to evaluate how changes in the token-production schedules associated with each schedule affects individuals' preferences for accumulated and distributed exchange-production schedules.

Experiment 3

Response Measurement

Paper-and-pencil data collection was used to record participants' behavior allocation using 10-s partial-interval recording. *Behavior allocation* was defined as the majority of the participant's body (i.e., all body parts above the waist) located on one side of the clinic room as separated by a piece of tape along the length of the floor dividing the room. *Preference* was defined as 75% or more intervals with allocation towards one token exchange-production schedule across four consecutive sessions.

Concurrent-Operant Preference Assessment

Preference for exchange-production schedules under varying token-production schedules was assessed via a concurrent-operant preference assessment. The clinic room contained a piece of tape along the length of the floor, dividing the room into two equal sides. One side was assigned to the accumulated exchange-production condition and the other side was assigned to the distributed exchange-production condition. The side of the room associated with each condition was quasi-randomized such that one side was not associated with a particular condition for more than three consecutive sessions. A separate token board was placed on each side of the room. During the concurrent-operant preference assessment, participants earned tokens for completing academic tasks (2:1 ratio of difficult to easy tasks identified during the demand assessment) located on either the accumulated or distributed exchange-production sides of the room. If the participant switched sides during a session, any tokens earned on one side of the room could not be used on the other side of the room. For example, if the participant earned tokens on the side of the room associated with the accumulated exchange-production schedule, these tokens could not be carried over and used on the side of the room associated with the distributed schedule. The accumulated and distributed exchange-production sides of the room were signaled by placing the laminated paper used in Experiments 1 and 2 signaling the distributed and accumulated schedules approximately 1 m from the floor on the wall on the relevant sides of the room. Sessions ended after 10 min (Sam and Dan) or 5 min (Ricky). Session time was adjusted by removing time spent trading in tokens and reinforcer-access duration. That is, the session timer was paused as soon as the participant placed the token board in the therapist's hand, and the session timer resumed at the start of the delivery of the next demand after the reinforcement interval had concluded.

At the start of each session, the therapist stated, "On this side of the room, you will earn one token for problems you do on this paper, and you can trade the token in right away [gestures to distributed side]. On this side of the room, you will earn one token for problems you do on this paper [gestures to accumulated side], and you can trade in the tokens you earned on this side as soon as you earn 10." Following an instance of compliance on the side of the room associated with the distributed exchange-production schedule, the therapist delivered brief, neutral praise (e.g., “good”) and one token (i.e., one tally on the token board). When the participant placed the token board in the therapist’s hand, the therapist paused the session timer and provided 30-s access to a preferred leisure item or 1 small piece of edible. Following an instance of compliance on the side of the room associated with the accumulated exchange-production schedule, the therapist delivered brief, neutral praise and one token. If the participant initiated the academic demand, but answered incorrectly, the therapist provided a vocal prompt. If the participant complied following the prompt and within 30 s of the initial demand, the therapist scored the response as compliance and delivered a token. If the participant answered incorrectly following the vocal prompt, the therapist provided a full-physical prompt paired with a vocal prompt, scored the response as noncompliance, and delivered the next demand. Following noncompliance, aggression, or property destruction, the therapist delivered a new academic demand. After the participant earned 10 tokens, the participant could exchange his accrued tokens, with each token worth 30-s access to his preferred activity or 1 small edible. The session timer stopped as soon as the participant placed the token board in the therapist’s hand.

The token-production schedules by which participants earned tokens for completing academic tasks increased across conditions, from FR 1 to VR 2 to VR 5 (or until the participant’s behavior allocation switched from one exchange-production schedule to another). Tokens earned on the distributed exchange-production side of the room were exchanged on an FR 1 exchange-production schedule (i.e., one token required to enter the exchange period), whereas tokens earned on the accumulated exchange-production side of the room were exchanged on an FR 10 exchange-production schedule (i.e., 10 tokens required to enter the exchange period). Accumulated tokens could carry over from one session to the next session (in the case that 10 tokens were not earned), but prior to beginning a new condition (i.e., moving from FR 1 to VR

2), any tokens earned on the accumulated side of the room were exchanged during the intersession interval (with each token exchangeable for 30-s access to tangibles or 1 edible) so that each phase began with zero tokens accrued on either side of the room.

Results and Discussion

Behavior allocation towards accumulated and distributed exchange-production schedules across FR 1, VR 2, VR 5, and VR 10 token-production schedules for Sam (top panel), Dan (middle panel), and Ricky (bottom panel) are displayed in Figure 6. Under initial FR 1 and VR 2 token-production schedules, Sam tended to allocate his responding towards the accumulated exchange-production schedules. When the token-production schedule changed from VR 2 to VR 5, his allocation towards the distributed exchange-production schedules increased and he allocated the majority of his responding towards the distributed exchange-production schedule by the end of the phase. During the reversal to VR 2, Sam engaged in varied responding towards the two exchange-production schedules. However, by the end of the phase, he allocated the majority of his responding towards the accumulated schedule. When the VR 5 token-production schedule was reintroduced, Sam switched his responding towards the distributed exchange-production schedule.

Dan exclusively allocated his responding towards the accumulated schedule under FR 1, VR 2, and VR 5 schedules of reinforcement. Dan initially continued to allocate responding towards the accumulated schedule during the VR 10 token-production schedule; however, he switched his responding towards the distributed schedules and showed a preference for the distributed exchange-production schedule by the end of the VR 10 phase. During the subsequent reversal to VR 5, Dan switched his responding back towards the accumulated schedule. When the VR 10 was reintroduced, Dan allocated his responding towards the distributed schedule.

Ricky initially allocated his behavior towards the accumulated exchange-production schedules under FR 1 token-production schedules. Under the VR 2 token-production schedule, Ricky's behavior allocation switched to the distributed exchange-production schedules. In the following return to FR 1, Ricky allocated his responding the accumulated schedules. During the reversal to the VR 2, Ricky continued to allocate this responding towards the accumulated schedule. Allocation towards the accumulated schedule continued during the VR 5 schedule. Ricky engaged in some variable responding when the VR 10 schedule was introduced, initially switching responding to the distributed schedule, but then allocating responding to the accumulated schedule. Ricky allocated responding towards the accumulated schedule during the return to the FR 1 token-production schedules. Under the following VR 10 and VR 2 schedules, Ricky switched his responding to the distributed exchange-production schedules. Ricky allocated his responding towards the accumulated schedules during the final return to an FR 1 schedule. He continued to allocate responding towards the accumulated schedule under the VR 5. During the return to VR 10, Ricky again allocated his responding towards the distributed exchange-production schedules.

Across participants there was an inverse relation between responding towards accumulated exchange-production schedules and token-production values. That is, participants generally allocated their behavior to accumulated exchange-production schedules under denser schedules of reinforcement (i.e., FR 1) but systematically preferred (i.e., allocate their behavior towards) distributed exchange-production schedules as token-production values increased to VR 5 (Sam) or VR 10 (Dan and Ricky).

Consistent with extant literature, changes in token unit price affected preferences for concurrently available schedules of reinforcement. That is, increasing token-production values in concurrently available schedules increased participants' preferences towards schedules with smaller response-reinforcer ratios (Madden et al., 2000). In clinical contexts, token-reinforcement programs generally involve leaner token-production schedules when possible for a variety of practical purposes (e.g., convenience, ease of implementation, availability of resources). Importantly, children may prefer accumulated exchange-production schedules under dense token-production schedules (i.e., FR 1), but prefer distributed schedules in settings with leaner token-production schedules (i.e., classroom environment). Thus, it is imperative that the effectiveness of, and individuals' preferences for, accumulated and distributed exchange-production schedules be assessed using token-production schedules similar to those used in applied settings, instead of richer token-production schedules commonly used in contemporary research investigating parameters of token exchange-production schedules (e.g., DeLeon et al., 2014).

General Discussion

Consistent with previous research (e.g., Ward-Horner et al., 2017), accumulated exchange-production schedules were more preferred (Sam, Dan, and Ricky), and supported higher rates of behavior for two (Sam and Dan) of three participants, than distributed schedules when participants earned tokens for completing easy academic tasks. With difficult tasks, accumulated schedules supported slightly higher rates of behavior than distributed schedules for two participants and were more preferred by two participants. With both easy (Sam, Dan, and Ricky) and difficult (Sam and Dan) tasks, participants' tended to prefer accumulated schedules relative to distributed schedules. Not surprisingly, overall rates of work completion were lower in conditions associated with hard tasks compared to easy tasks across distributed and accumulated exchange-production schedules. Under continuous reinforcement schedules, all three participants preferred accumulated exchange-production schedules when they had concurrent availability to accumulated and distributed schedules (Experiment 3). However, as token-production schedules increased, participants' preferences ultimately switched to distributed exchange-production schedules. This preference switch is consistent with research suggesting organisms' behavior allocation among concurrently available schedules of reinforcement is affected by changes in the schedule work-reinforcer ratios (e.g., Borrero et al., 2007; Tustin, 1994). In contrast to Delmendo et al. (2009), preferences for these concurrently-available exchange-production schedules were not equivalent under large and small unit prices even though the reinforcement ratio for distributed and accumulated exchange-production schedules (1:10) was held constant across increasing token-production schedules (see Madden et al., 2000).

The results of the current project add to the extant literature in several ways. First, results from Experiment 1 replicate results from DeLeon et al. (2014) and others (see Ward-Horner, 2017) suggesting that continuous (i.e., accumulated) work-reinforcer schedule arrangements are generally more preferred and effective than discontinuous (i.e., distributed) schedule arrangements despite the associated delays to reinforcement in the continuous schedule configurations. Second, current research indicates the response effort associated with schedules of reinforcement may affect preferences for concurrently available delayed and immediate reinforcement schedules (e.g., Neef et al., 2005; Perrin & Neef, 2012). The current project extends this literature base by examining the effects of tasks difficulty on the effectiveness and preference of accumulated and distributed exchange-production schedules. Notably, token-reinforcement programs are likely to be used in clinical contexts associated with high-effort tasks (e.g., difficult tasks, acquisition of new skills), and increases in response effort have been shown to affect individuals' preferences for delayed versus immediate schedules of reinforcement (e.g., Lerman et al., 2006; Neef et al., 2005; Perrin & Neef, 2012). Importantly, 2 of 3 participants continued to prefer accumulated schedules under increased response-effort requirements. Additionally, token-reinforcement programs in clinical contexts may use relatively lean token-production schedules. In the current study, increasing the token-production schedule affected preferences for delayed and immediate exchange-production schedule arrangements.

One limitation of the current study is that the sequence of easy and difficult reinforcer assessments and preference assessments was not varied across participants. Participants' exposure to delayed contingencies under easy response requirements may have partially established the reinforcing value of tokens earned in accumulated exchange contexts that affected their subsequent behavior under more difficult task requirements. Thus, future research in this area might involve varying the sequence and interspersal of easy and difficult academic tasks to further evaluate the impact of task difficulty on preference and effectiveness of accumulated and distributed schedules while controlling for potential sequence effects.

Participants in the current project could exchange tokens for both edible and tangible backup reinforcers. DeLeon et al. (2014) found differences in preferences for accumulated and distributed schedules by reinforcer type (i.e., food vs activity reinforcer), with activity reinforcers associated with increased preference for accumulated schedules compared to edible reinforcers. Although our results were consistent with DeLeon et al. (2014), it is possible that our participants' preferences for accumulated exchange-production schedules would have been more pronounced if we exclusively used activity-based backup reinforcers. We opted to allow participants to exchange tokens for both edible and activity-based reinforcers for two main reasons. First, anecdotal observations prior to the study suggested that our participants seemed to prefer simultaneously consuming multiple edibles rather than one edible at a time. Second, token-reinforcement programs in many applied settings incorporate both edible and tangible backup reinforcers (e.g., Parry-Cruwys et al., 2011). However, future research should evaluate if preferences for accumulated schedules under increased work requirements or leaner token-production schedules are affected if only one type (i.e. edible vs activity) of backup reinforcer is used.

Findings from the current study indicate that accumulated exchange-production schedules are often preferred and effective within token reinforcement arrangements with children with challenging behavior. Importantly, accumulated exchange-production schedules may promote self-control, as children learn to tolerate delays to reinforcement to contact larger magnitude reinforcers. Clinicians should note that accumulated schedules are likely most preferred and effective in token-reinforcement contexts associated with easy task completion and dense token-production schedules. To promote preferences for accumulated schedules under leaner token-production schedules or in more difficult work completion contexts, delay fading (e.g., Dixon et al., 1998) or delay tolerance training (Hanley, Heal, Tiger, & Ingvarsson, 2007) may be necessary as future researchers evaluate procedures for increasing preference for accumulated exchange-production schedules.

Additional research should further assess the demand for reinforcers under different token-production and exchange-production schedules to identify schedules that support the greatest response output at the lowest prices. As described by Delmendo et al. (2009), evaluating demand elasticity allows clinicians to identify inelastic areas of demand functions for various reinforcers and schedules of reinforcement to maximize response effort at the lowest possible reinforcer amount. In other words, evaluating schedules of reinforcement within a unit-price framework may have significant clinical utility, allowing clinicians to arrange contingencies that support maximal levels of responding for minimal programmed reinforcer delivery. Using this principle of demand elasticity, for example, might allow clinicians to determine the fewest number of tokens that will still effectively maintain appropriate behavior (e.g., compliance with adult demands) in a token economy. Furthermore, researchers should identify procedures for increasing individuals' preferences for delayed reinforcement associated with accumulated exchange-production schedules under leaner token-production schedules using demand or delay fading procedures (e.g., Neef et al., 2001) or yoking token-exchange schedules to token-production schedules to maintain higher levels of reinforcement during increased work requirements or delays to reinforcement. Future research involving the assessment and modification of impulsive choice within token-reinforcement contexts will serve to enhance the clinical outcomes of contingency-based interventions in applied settings while also adding to the nomological network of translational behavior-economic research.

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Table 1.

Easy and Difficult Tasks by Participant

Participant	Easy Tasks	Hard Tasks
Sam	1 Letter Spelling 2 Letter Spelling 3 Letter Spelling 1 Digit Addition 1 Digit Subtraction	4 Letter Spelling 5 Letter Spelling 1 Digit Multiplication
Dan	4 Letter Spelling 1 Digit Addition 1 Digit Subtraction 2 Digit Addition 2 Digit Subtraction	5 Letter Spelling 2 Digit Multiplication
Ricky	3 Letter Spelling 4 Letter Spelling 5 Letter Spelling 6 Letter Spelling 8 Letter Spelling	1 Digit Addition 1 Digit Subtraction 1 Digit Multiplication 1 Digit Division

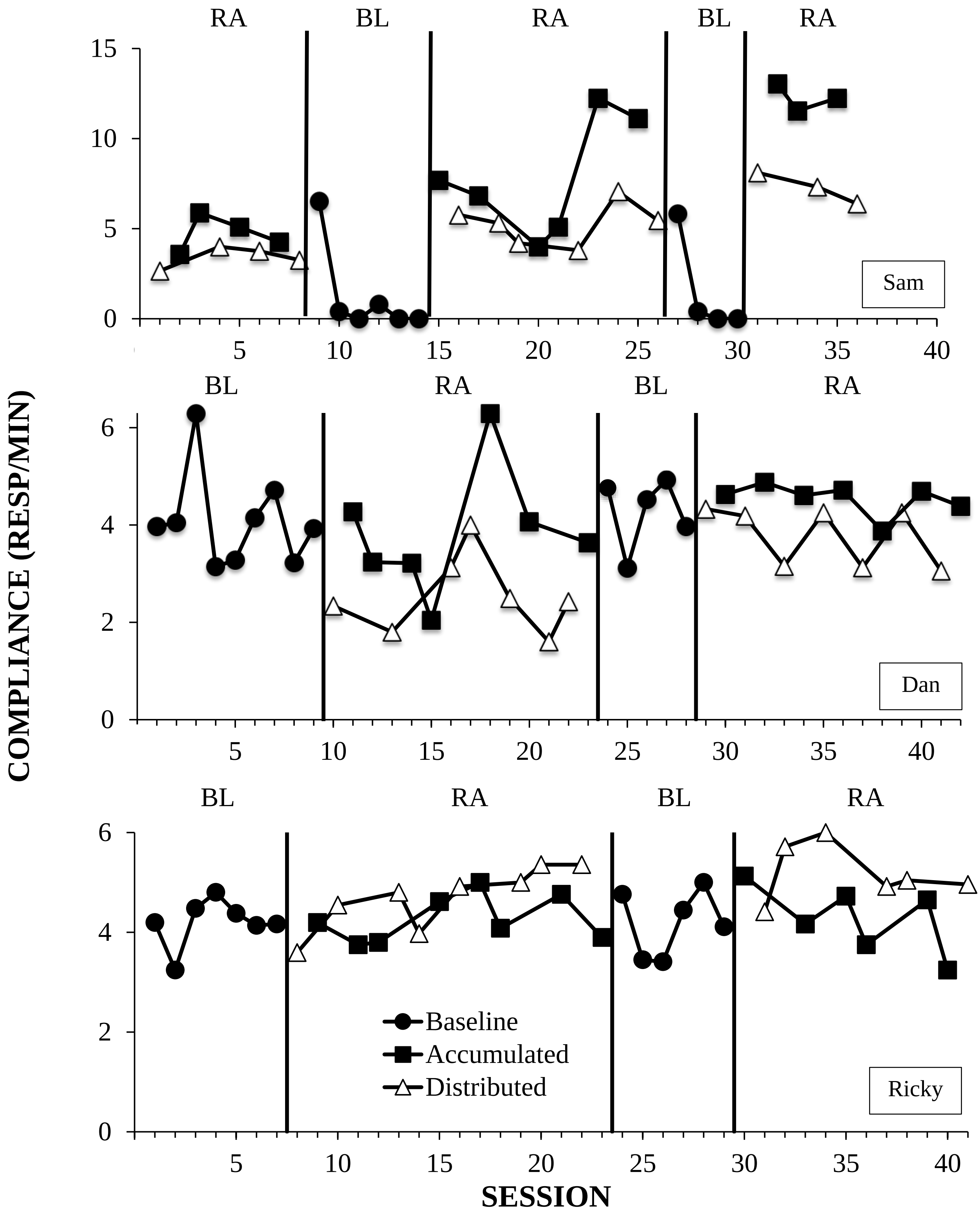

Figure 1. Rate (resp/min) of compliance with easy academic directives across baseline (BL), distributed, and accumulated reinforcer assessment (RA) conditions for Sam (top panel), Dan (middle panel), and Ricky (bottom panel).

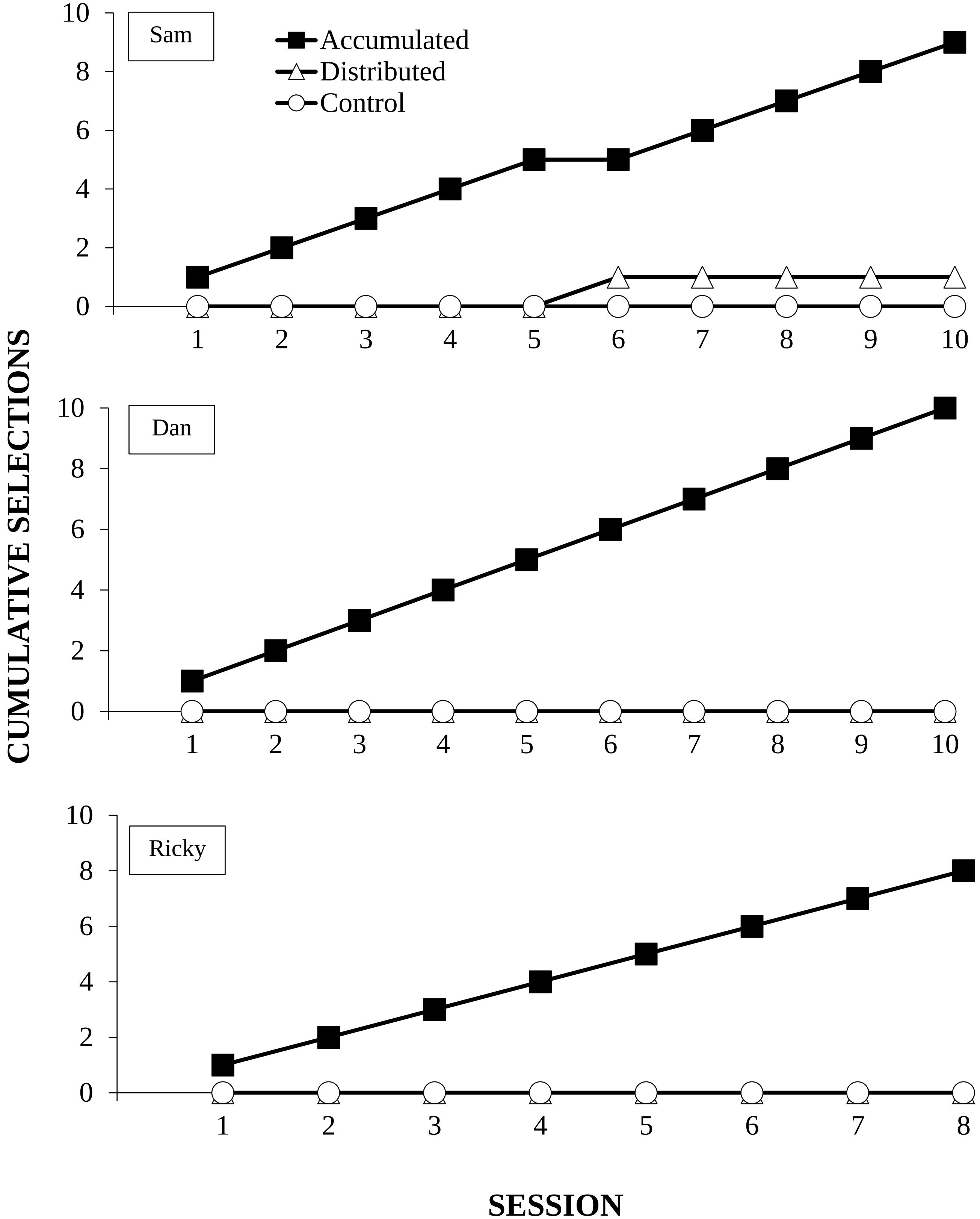

Figure 2. Cumulative selections for accumulated, distributed, and control conditions across easy academic directives for Sam (top panel), Dan (middle panel), and Ricky (bottom panel).

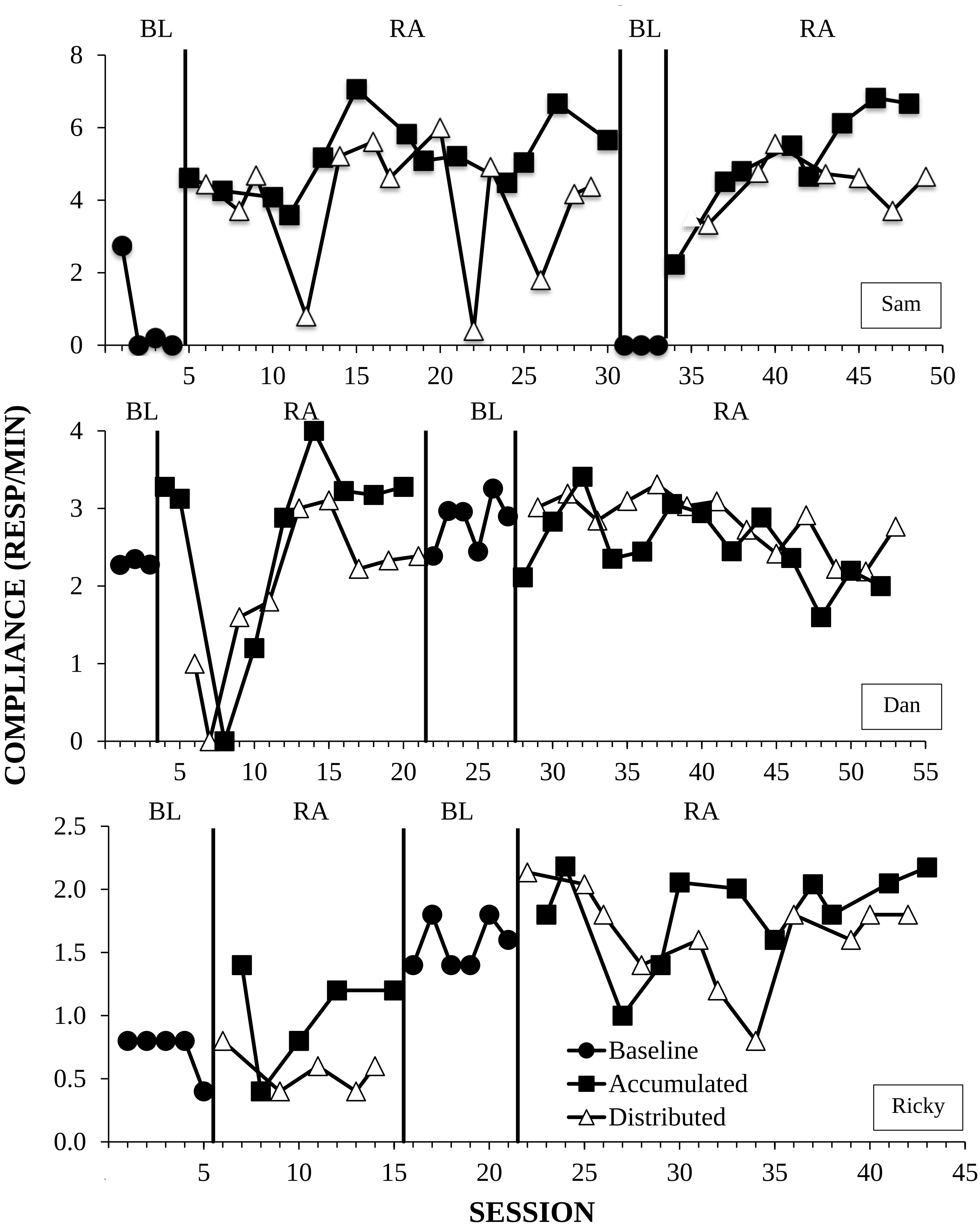

Figure 3. Rate (resp/min) of compliance with hard academic directives across baseline (BL), distributed, and accumulated reinforcer assessment (RA) conditions for Sam (top panel), Dan (middle panel), and Ricky (bottom panel).

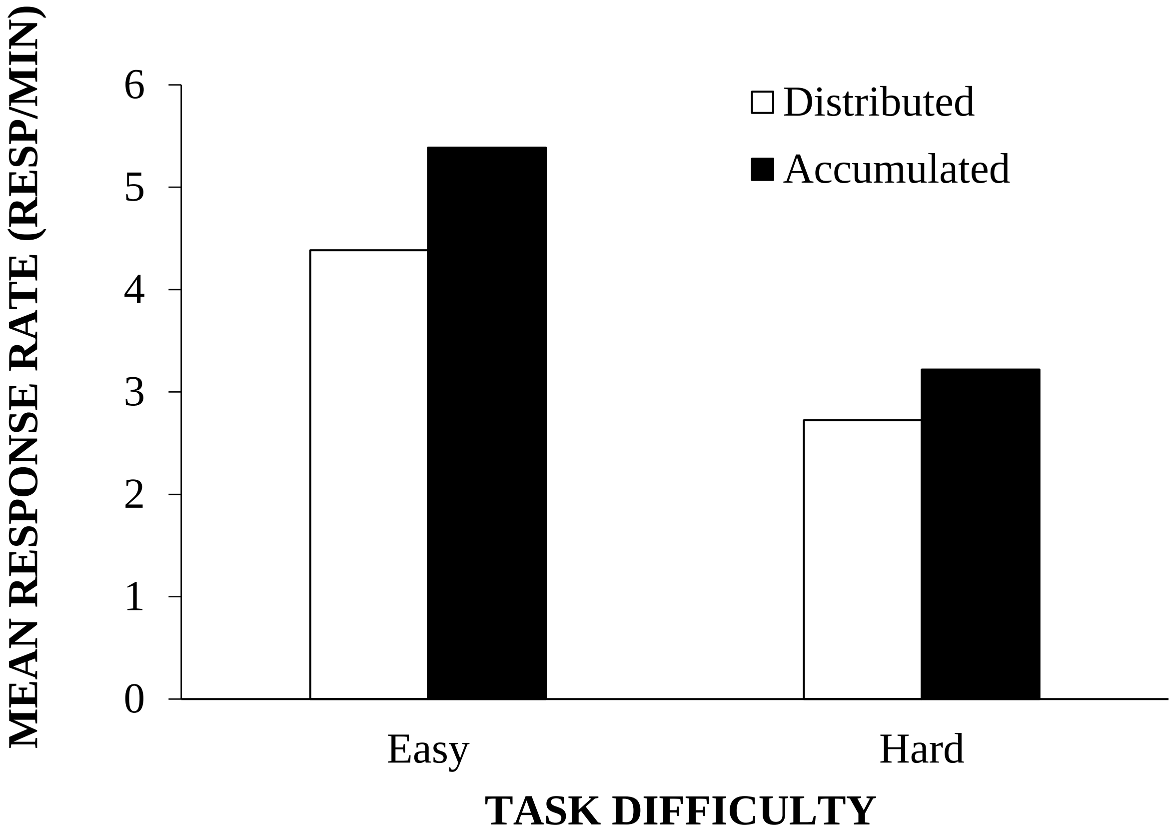

Figure 4. Mean rate of compliance under distributed and accumulated exchange-production schedules across easy and hard tasks.

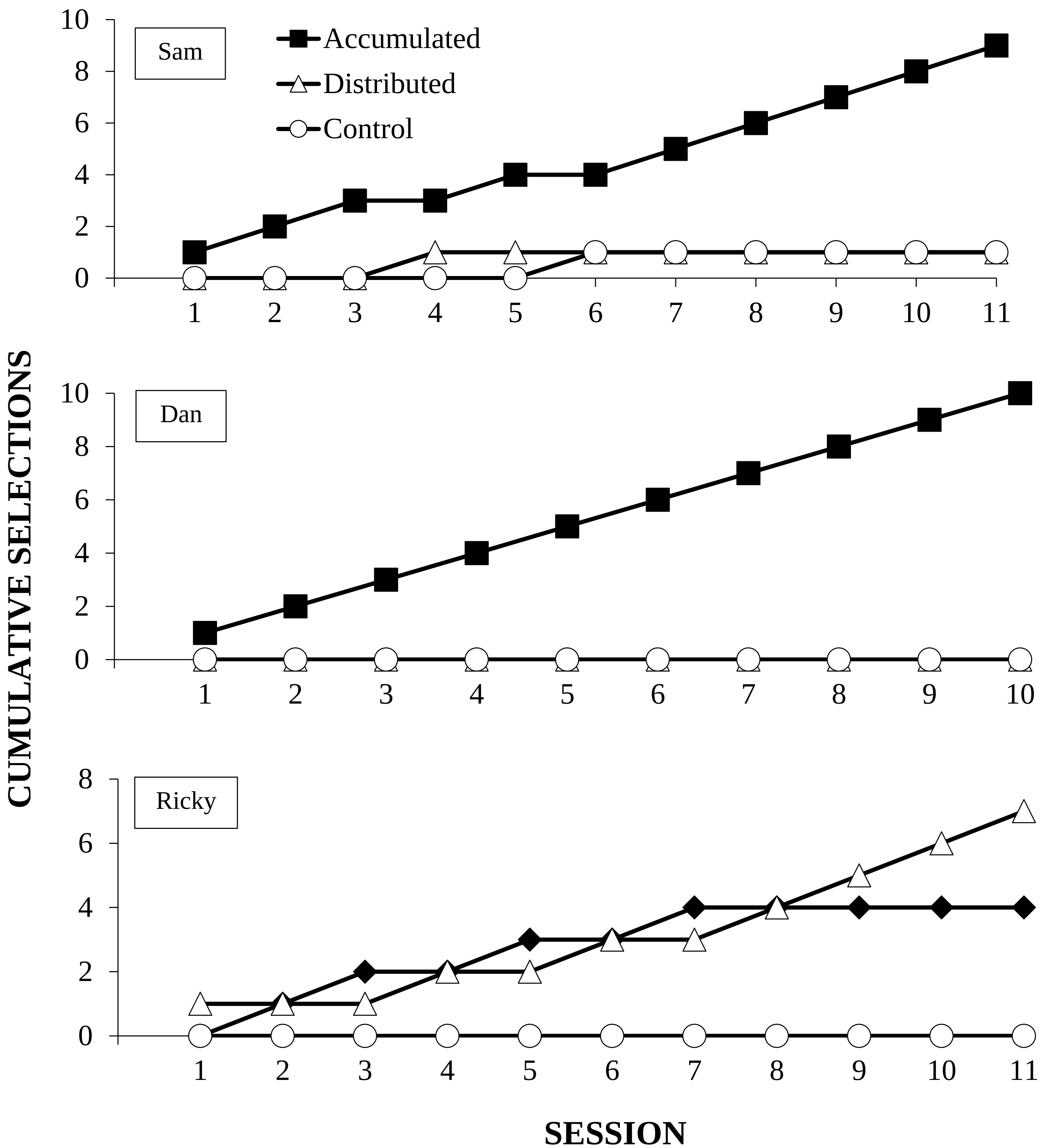

Figure 5. Cumulative selections for accumulated, distributed, and control conditions across hard academic directives for Sam (top panel), Dan (middle panel), and Ricky (bottom panel).

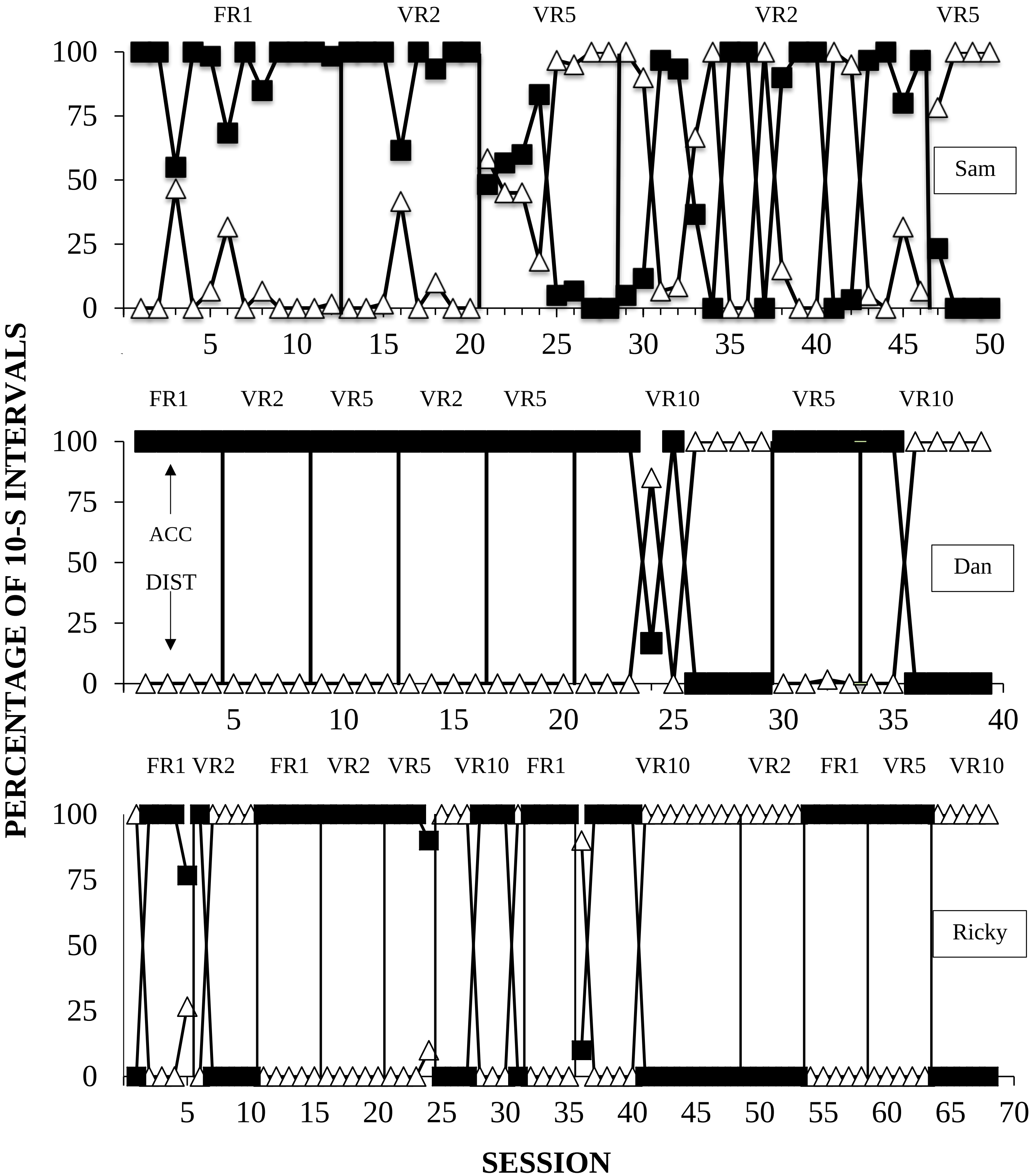

Figure 6. Behavior allocation towards accumulated and distributed exchange-production schedules across FR 1, VR 2, and VR 5, and VR 10 token-production schedules for Sam (top panel), Dan (middle panel), and Ricky (bottom panel).