ANALYSIS OF PREFERENCE FOR TOKEN ACCUMULATION IN HUMANS: TWO NOVEL DEMONSTRATIONS

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Although a variety of basic research has examined variables that affect token accumulation in token-reinforcement contexts, there is relatively little translational research in this area. Through two brief demonstrations, the purpose of the current study was to a) replicate basic findings which suggest token accumulation decreases as a function of increasing token-production schedules and b) examine how preferences for accumulated token exchange-production schedules are influenced by interactive effects of psychotropic medications and classes of stimuli used as backup reinforcers. Apart from extending basic token research findings to applied contexts, these two translational demonstrations may serve as a proof of concept for future applied token accumulation research.

Keywords: accumulation; atypical antipsychotic; exchange-production schedules; preference; tokens

There are three components of token-reinforcement procedures that may influence organisms' preferences for (and the efficacy of) various token arrangements. These components involve the token-production schedule, the token-exchange schedule, and the token exchange-production schedule. The token-production schedule specifies the number of responses required to earn a token. For example, under a fixed-ratio (FR) 5 token-production schedule, one token would be delivered following every five responses. The token-exchange schedule specifies the schedule by which tokens are exchanged for backup reinforcers (Hackenberg, 2009); in other words, these schedules specify 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; a FR-5 token-exchange schedule would specify that each token is worth five units of the backup reinforcer (e.g., Falligant & Kornman, 2019). Finally, 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). For example, under an FR-10 exchange-production schedule (i.e., an accumulated schedule), tokens cannot be exchanged for backup reinforcers until the individual has accumulated 10 tokens. In contrast under a FR-1 exchange-production schedule (i.e., a distributed schedule), each token can be exchanged as soon as it is earned.

Given that exchange-production schedules may affect the magnitude, duration, or continuity of reinforcer access, as well as relative work requirements and commensurate delays to reinforcement in token-reinforcement contexts (Hackenberg, 2009), these schedules are the focus of much interest in basic research contexts (e.g., Bullock & Hackenberg, 2006). Recently, applied researchers have also studied different parameters of exchange-production schedules in clinical contexts. For example, DeLeon et al. (2014) demonstrated that, among a sample of four individuals with intellectual and developmental disabilities (IDDs), accumulated exchange-production schedules were preferred relative to distributed exchange-production schedules when tokens were exchanged

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for activity-based reinforcers. Additionally, all four participants' rates of work completion were considerably faster in accumulated schedules relative to distributed schedules when they earned tokens that were exchanged for activity-based reinforcers.

A variety of research has examined factors that influence preferences for accumulated exchange-production schedules and token accumulation in basic research preparations with nonhuman organisms (e.g., Yankelevitz et al., 2008). However, comparatively little research in these areas has been conducted in translational and applied contexts with humans. Identification of factors that affect token accumulation and preferences for larger exchange-production schedules in research contexts with humans has both scientific and clinical value, allowing researchers to a) further explicate variables that affect "self-control" (i.e., preference for delayed, denser schedules of reinforcement relative to more immediate, leaner schedules of reinforcement), and b) identify conditions in which token accumulation is more or less likely to occur. To the extent that clinicians can promote token accumulation in applied situations, clients contact greater periods of reinforcement and learn important self-control skills. Though relatively unexplored in applied preparations, two contextual variables that may affect token accumulation involve a) differences in token-production schedules, and b) interactive effects between psychotropic medications and affinity for classes of stimuli used as backup reinforcers.

Recently, Glodowski et al. (2019) compared token and tandem schedules of reinforcement on response patterns with adolescents with autism. Their results were partially consistent with basic findings suggesting that tokens may suppress responding (relative to tandem schedules) under increasing token-production schedule values (e.g., Bullock & Hackenberg, 2015; Gadaire et al., 2019). Relatedly, Yankelevitz et al. (2008) found that token accumulation may decrease as a function of increasing token-production schedule values, and accumulation may be enhanced in token reinforcement (relative to tandem schedules of reinforcement) conditions. Thus, it is unknown if a) accumulation is diminished under leaner token-production values, b) differences in accumulation under token and tandem schedules occur, and c) whether such differences may be more likely to occur under relatively dense token-production schedules.

In addition, preliminary research indicates that token accumulation may vary based on the type of available backup reinforcers (i.e., edible vs. activity). That is, for some individuals, accumulated schedules may be preferred for activity-based backup reinforcers but not for edible reinforcers (DeLeon et al., 2014). However, it is unknown how other clinical variables, including use of psychotropic medication, may also affect preferences for different exchange-production schedules. The impact of medication on schedule preferences is worth exploring given a) the widespread use of psychotropic medication (in particular, antipsychotic medication) for individuals with IDD and disruptive behavior, and b) the effects of atypical antipsychotics on relevant establishing operations (i.e., increased appetite, insulin insensitivity; Parsons et al., 2009) that may affect the value of edible reinforcers. Thus, changes in the administration of these agents may affect the reinforcing value of edible stimuli and produce concomitant changes in preferences for exchange-production schedules.

Together, the purpose of the current study was to examine whether token accumulation decreases as a function of

increasing token-production schedules (e.g., Yankelevitz, 2008; Demonstration 1), as well as replicate results from DeLeon et al. (2014) and parametrically evaluate the effects of dosage changes of aripiprazole on exchange-production schedule preferences (Demonstration 2). Though these are preliminary investigations, these two demonstrations may serve as a proof of concept to build upon for future token accumulation research.

METHOD

Participants and Setting

Nick was a 12-year-old male diagnosed with autism spectrum disorder (ASD) admitted to an inpatient hospital unit for the assessment and treatment of aggression and disruptive behavior. James was an eight-year-old male diagnosed with high-functioning ASD admitted to an outpatient clinic for assessment and treatment of aggression and disruptive behavior. Results from a functional analysis indicated Nick's problem behavior was maintained by social attention and escape from demands, and James' problem behavior was maintained by escape from demands. Both participants communicated vocally using full sentences and had completed token training as part of behavioral treatment for severe problem behavior (data available from corresponding author).

Sessions were conducted in clinic rooms (approximately 8m x 8m) two days per week in the afternoon for approximately 45 to 90 min per day (allowing for multiple sessions per day). Rooms contained two chairs, a desk, and relevant session materials. The therapist used an erasable marker or pencil to provide tokens (tallies) on the token board (laminated sheet of paper or piece of blank paper). Academic materials (i.e., addition and subtraction worksheets) were obtained from participants' existing educational programs.

Nick was prescribed various doses of aripiprazole as part of an ongoing clinical medication trial ranging from 7 mg to 17.5 mg per day. Note that neither the timing of aripiprazole administration (morning or evening), nor the proximity of mealtime to the administration of aripiprazole affects metabolism of the drug (e.g., Davie et al., 2004). Sessions were not conducted until a minimum of four days had passed following each medication increase (see Davies et al., 2004 for a review of aripiprazole pharmacokinetics).

Response Measurement and Interobserver Agreement

Paper-and-pencil data collection was used to record the frequency of completion within 10-s intervals across sessions. Frequency data for work completion (i.e., each academic problem) were recorded and converted to rate (responses per min) for each session. Completion was defined as any instance of the participant finishing the academic task within 30 s of initiating the demand (independently or with a vocal-model prompt) in the absence of problem behavior. For Nick, we also collected frequency data for selections for the accumulated, distributed, and control schedules within the modified concurrent-chains preference assessment.

Interobserver agreement (IOA) was calculated on an interval-by-interval basis for the token evaluation and on a trial-by-trial basis for the token accumulation and modified concurrent-chain preference assessment. 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. IOA was collected on 37% of sessions with Nick and averaged 99.8% (range, 97%-100%); IOA was collected on 39% of sessions with James and averaged 99.3% (range, 80%-100%).

DEMONSTRATION 1

Token Accumulation Assessment

Token condition. In this condition, James earned tokens for competing mastered academic demands (e.g., math worksheet problems, spelling problems) each session. Following a correct response (either independently or following a model prompt if the participant made an initial error), the experimenter delivered tokens according to the specified token-production schedule for each academic problem completed. Earned tokens were placed in front of James in a clear container. Each token was worth one small edible or 30-s access to an activity-based reinforcer. Backup reinforcers were identified based on results of previously conducted stimulus preference assessments and other clinical data; they were selected at each exchange opportunity. At the start of each session, the therapist detailed the contingencies to James, and said "It's time to do some work. You can do as many of these problems as you want. Let me know when you're done working." Sessions were terminated after James emitted a communicative response terminating the session (e.g., "I'm done") or 1 min elapsed in the absence of completion of an academic task. The participant would exchange the tokens by placing them in the therapist's outreached hand. All problem behavior was ignored. Sessions were conducted for the following token-production components: FR 1, FR 2, FR 5, VR 2, VR 5. These were conducted in six-session blocks, in which token condition sessions alternated with tandem condition sessions (see below) on a quasi-random basis within each block (see Table 1).

Tandem condition. These sessions were identical to the token condition sessions, except the therapist did not deliver tokens for completion of academic tasks—instead, the therapist tracked the number of tasks that were completed, and delivered the commensurate number of backup reinforcers at the end of session. At the start of each session, the therapist detailed the contingencies to James, and said "It's time to do some work. You can do as many of these problems as you want. I will keep track of the problems you complete and tell you how much you have earned at the end. Let me know when you're done working."

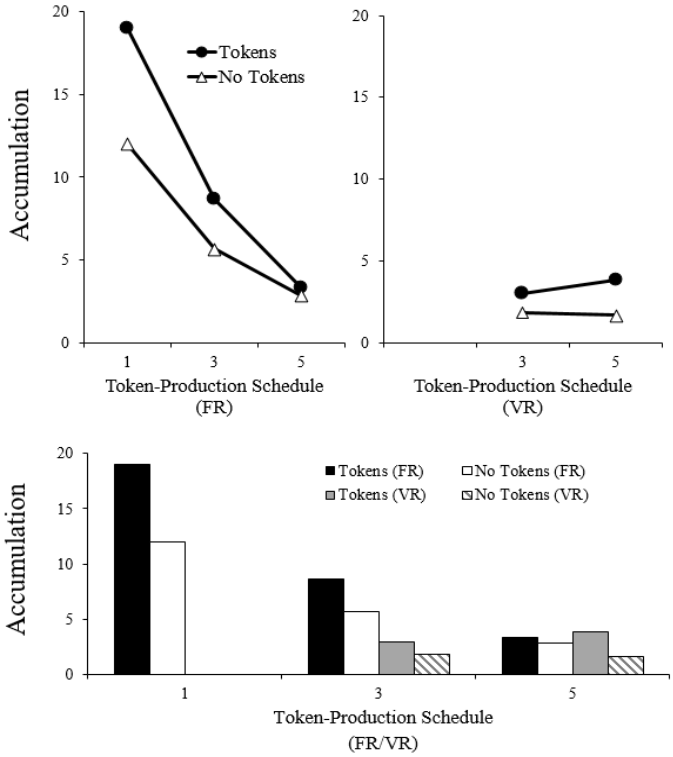
RESULTS AND DISCUSSION

Under FR token-production schedules, James consistently accumulated more reinforcers in the token condition relative to the tandem condition; across both conditions, his mean token accumulation varied inversely with the token-production schedule (Figure 1). A similar pattern emerged under VR token-production schedules, although decreases in accumulation were more pronounced in VR 3 and VR 5 components relative to FR 3 and FR 5 components. Together these

Table 1.
Programmed and obtained schedule values.

Condition	Token	Tandem	Obtained VR Value
FR1	3	3	-
FR3	3	3	-
FR5	3	3	-
FR1	3	3	-
VR3	3	3	3.1
VR5	3	3	5.08
FR1	3	3	-
FR3	3	3	-
FR5	3	3	-
FR1	3	3	-
VR3	3	3	3.3
VR5	3	3	5

Figure 1.
Token accumulation across schedule values.



results replicate Yankelevitz et al. (2008), indicating that mean token accumulation decreases as a function of increasing token-production schedules. However, similar to Yankelevitz et al., mean accumulation was greater in the token condition relative to the no-token (i.e., tandem) condition. Mean differences in responding between the token and tandem schedules primarily occurred under dense (i.e., FR 1, FR 3) token-production schedules; there were minimal differences in reinforcer accumulation between the token and tandem schedules under leaner (FR 5) schedules (cf. Glodowski et al., 2019). Though it would be premature to draw conclusions for clinical practice from this demonstration, this preparation may serve as a useful proof of concept for future research and replications in this area. Additional research might also evaluate the demand elasticity of tokens earned under different token-production and schedule arrangements (FR vs VR, token vs tandem; e.g., Argueta et al., 2019) to identify inelastic areas of demand for tokens or backup reinforcers in order to maximize work-reinforcer ratios.

DEMONSTRATION 2

Token Evaluation and Concurrent-Chains Preference Assessment

Procedures for this evaluation were modeled from those described by DeLeon et al. (2014). Briefly, we used a within-subject ABAB reversal with embedded multielement design followed by a modified concurrent-chains preference assessment in which Nick selected the exchange-production schedule for each session. At the beginning of each choice trial, the therapist stated, "It's time to do some

work. Which way would you like to work and earn tallies?" Following the selection, the therapist implemented the corresponding condition as described below. Each schedule condition was signaled with a vocal instruction and a laminated sheet of paper (21 cm x 28 cm) placed in front of Nick. Tokens were always exchanged for edible backup reinforcers. Nick would exchange the tokens by placing the token board in the therapist's outreached hand. Backup reinforcers were identified based on results of previously conducted stimulus preference assessments and other clinical data; they were selected at each exchange opportunity.

The effects of aripiprazole on Nick's preference for accumulated and distributed token exchange-production schedules were evaluated using a quasi-experimental parametric approach. That is, the concurrent-chains preference assessment was conducted at three different points during the course of multiple scheduled medication adjustments (in which his daily aripiprazole dosage was increased from 7.5 mg to 15 mg to 17.5 mg) over the course of a 21-day period. These medication changes were made by Nick's psychiatrist in the course of ongoing medical services.

Control. The control condition was signaled by a picture of an "X" on Nick's desk. These sessions served as the baseline phase in the token evaluation. Prior to the start of each session, the therapist placed the token board in front of the participant and stated, "It's time to do some work. You can do these problems if you want, but you will not earn any tokens." The therapist then placed an academic worksheet in front of Nick. The therapist delivered neutral praise (e.g., "good") for each problem Nick completed. If Nick completed a problem incorrectly, the therapist provided a vocal-model prompt (e.g., "12 plus 12 equals 24"). If the participant answered correctly following the prompt, the therapist scored the response; if Nick answered incorrectly following the prompt, the therapist did not score the response as complete and prompted Nick to complete the next problem. Sessions ended after either (a) 10 min expired, (b) 1 min elapsed without completing any work, or (c) Nick complied with 10 demands (whichever occurred first).

Distributed. The distributed condition was signaled by a picture of a single coin. Prior to the start of session, the therapist placed the token board in front of Nick and reviewed the token exchange-production procedure (e.g., "When you complete a problem, you will get one tally right away to trade for one small piece of snack"). For each problem that Nick completed under this schedule, the therapist delivered a tally on the token board and neutral praise by saying "you earned a token." If Nick completed a problem incorrectly, the therapist provided a vocal-model prompt. If he answered correctly following the prompt, the therapist scored the response as complete and delivered a token; if Nick answered incorrectly following the prompt, the therapist did not score the response as complete or deliver a token, and prompted Nick to complete the next problem. As soon as the response requirement was met (1 token), the therapist paused the session timer and provided one small edible. The timer resumed once Nick consumed the edible.

Accumulated. The accumulated condition was signaled by a picture of a stack of coins on Nick's desk. Prior to the start of session, the therapist placed the token board in front of Nick and reviewed the token exchange-production procedure (e.g., "When you complete a problem you will get one tally, and you can trade all of your tallies in after you have finished working"). For each problem that Nick completed, the

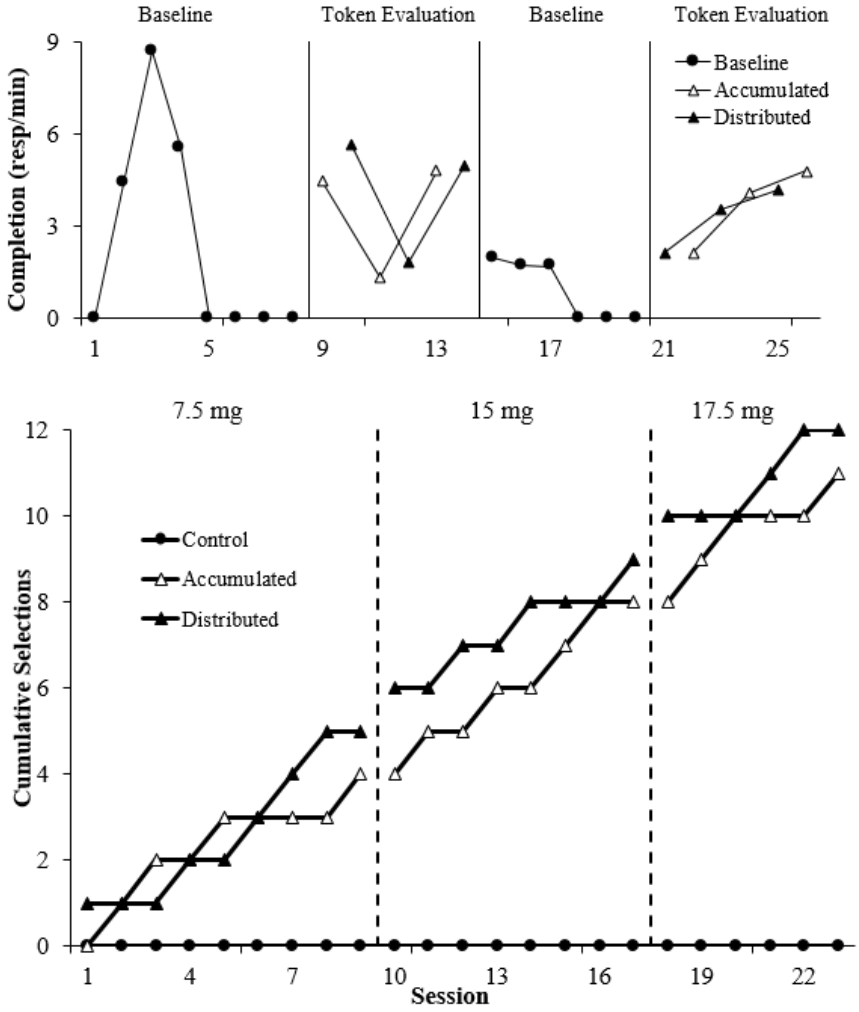
therapist delivered a tally on the token board and neutral praise by saying "you earned a token." If Nick completed a problem incorrectly, the therapist provided a vocal-model prompt. If the participant answered correctly following the prompt, the therapist scored the response as complete and delivered a token; if Nick answered incorrectly following the prompt, the therapist did not score the response as complete or deliver a token, and prompted him to complete the next problem. As soon as the response requirement was met (10 tokens), the session timer stopped and Nick selected his 10 edibles to consume.

RESULTS AND DISCUSSION

Rates of work completion are displayed in Figure 2 across baseline and token-evaluation sessions. During initial baseline sessions, Nick's rates of work completion were variable (see Glodowski et al., 2019) but generally very low and stabilized at 0 for multiple consecutive sessions (M = 2.3); rates increased in the subsequent accumulated (M = 3.5) and distributed (M = 4.1) token evaluation condition sessions. Rates of work completion decreased in the return to baseline (M = 0.9) before increasing again in the following accumulated (M = 3.7) and distributed (M = 3.3) token

Figure 2.

Efficacy of and preference for exchange-production schedule arrangements.



evaluation condition sessions. Nick's cumulative selections for accumulated and distributed exchange-production schedules during the modified concurrent-chains preference assessment are displayed in Figure 2. Nick selected the distributed exchange-production schedule on 5 of 9 (7.5 mg), 4 of 8 (15 mg), and 3 of 6 (17.5 mg) sessions, indicating a relative indifference between accumulated and distributed exchange-production schedules across medication dosages

Similar to two participants from DeLeon et al. (2014), accumulated schedules were not associated with increased work completion relative to distributed schedules with edible-based backup reinforcers. Moreover, there was not a strong preference for one schedule over the other. Interestingly, relative preferences for accumulated and distributed schedules did not vary despite two separate increases in Nick's aripiprazole dosage. This outcome supports the hypothesis that accumulated schedules may be preferable to the extent that they enhance continuity of reinforcer access to activity-based stimuli but not necessarily other stimuli for which continuity of access is less important (i.e., food). These outcomes *may* indicate that preferences for exchange-production schedules are stable and may remain fairly consistent across changes in different organismic states (e.g., changes in satiety or hunger). To the degree these findings are replicated in future research, these results could suggest that aripiprazole does not necessarily alter the reinforcing or appetitive value of tokens earned under different exchange-production schedules. However, given very small sample size and fact that there is no comparison to non-food reinforcers (in addition to other weaknesses; e.g., lack of reversals of medication dosages), it would be premature to comment on the extent to which preferences for these exchange-production schedules is affected by the type of backup reinforcer (i.e., food-based) and drug-related changes. Regardless, the methods utilized within this demonstration suggest how preferences for token accumulation via exchange-production schedules across different medication changes may be evaluated using a similar approach in future research.

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