An Assessment of Token Value and Effectiveness

By

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Abstract

Token systems are a commonly used treatment procedure to increase levels of a desired behavior (e.g., compliance) or decrease levels of an unwanted behavior (e.g., aggression) for a variety of different responses (Hackenberg, 2009). Token systems have been used with a variety of populations including, but not limited to, children diagnosed with disabilities, prisoners, and school children. Because token systems are commonly used, it is important to identify the reinforcing value of these systems to increase their effectiveness (Fiske et al., 2015). Fiske et al. (2015) used progressive-ratio schedules to compare the effects of paired tokens, primary reinforcers, and unpaired tokens on the number of responses completed by two children diagnosed with autism. The results showed for both participants that responding was variable during the paired token condition, stable during the primary reinforcement condition, and low during the unpaired token condition. The purpose of the current study was to conduct a systematic replication of Fiske et al. (2015) to extend the behavior-analytic literature on token reinforcement in applied settings. Specifically, we addressed several of the limitations of Fiske et al. (2015) by (a) including specific conditioning procedures and creating a controlled history of reinforcement with the token system, (b) including participants with and without disabilities to extend the generality of the findings, and (c) equating the magnitude of reinforcement across the primary and paired token conditions. The reinforcing value of tokens was evaluated by using progressive-ratio schedules to compare the efficacy of primary reinforcement, paired tokens, and unpaired tokens on the level of task completion.

Keywords: token reinforcement, token economy, conditioned reinforcement, reinforcement, reinforcer assessment, progressive-ratio schedule

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Token reinforcement systems involve the use of conditioned reinforcers (e.g., tokens) that are delivered contingent on a specific behavioral criterion. Individuals then exchange these conditioned reinforcers for back-up reinforcers. Token systems are a commonly used treatment procedure to increase or decrease a variety of different responses (Hackenberg, 2009). Tokens have been used with a variety of populations, such as children diagnosed with disabilities (e.g., Charlop-Christy & Haymes, 1998; Tarbox et al., 2006), prison inmates (e.g., Bassett & Blanchard, 1977; Milan & McKee, 1976), and employees (e.g., Fox et al., 1987).

There are a variety of potential benefits to using conditioned reinforcers (Hackenberg, 2009). First, conditioned reinforcers can bridge the temporal gap between a response and the delivery of a back-up reinforcer, which may help decrease problem behavior during delays (Hackenberg, 2009). Second, conditioned reinforcers can be delivered immediately in situations in which the actual reinforcer cannot be delivered (Hackenberg, 2009). Third, the number of tokens quantitively represents the number of reinforcers earned (Ayllon & Azrin, 1968), thereby signaling to the therapist and the client how much reinforcement has been, or will be, earned (Kelleher, 1966). Additionally, if the tokens quantitatively represent the amount of reinforcement earned, presumably earning more tokens may increase the value of tokens. Fourth, tokens are portable and easy to deliver (Ayllon & Azrin, 1968). Finally, conditioned reinforcers can be paired with one or multiple back-up reinforcers. When conditioned reinforcers (e.g., tokens) are paired with multiple back-up reinforcers, they become generalized conditioned reinforcers (Skinner, 1953). Generalized conditioned reinforcers are less susceptible to the effects of satiation because the conditioned reinforcer can be exchanged for a variety of reinforcers (Catania, 2013).

Token systems can be used in a variety of ways, including token reinforcement (e.g., token boards) and token economies. Token reinforcement is a system in which tokens are acquired and exchanged for reinforcement on a specified schedule. A token reinforcement system may involve a token board in which tokens are earned on a specific token-production schedule and then those tokens are exchanged on a specific exchange-production schedule for a back-up reinforcer. Additionally, all tokens are exchanged during the exchange-production schedule.

A token economy is a specific token reinforcement system in which tokens (conditioned reinforcers) are acquired, accumulated, and exchanged for reinforcers (Ayllon & Azrin, 1965). The key feature of a token economy is that back-up reinforcers are arranged such that various back-up reinforcers have different values. Essentially, within a token economy, tokens function as money does in everyday society. A token economy may involve a system in which tokens are earned on a specific token-production schedule and then those tokens are exchanged based on a specified exchange-production schedule for back-up reinforcers. However, back-up reinforcers may be differentially priced, and the individual has the opportunity save or accumulate their tokens, whereas many token systems are simpler without differential pricing and options for accumulation. There is a substantial literature base dedicated to token economies across a variety of populations and settings.

Doll et al. (2013) and Ivy et al. (2017) reviewed the literature involving token systems and the various settings and populations in which the systems have been used. Despite the difference between token reinforcement and token economies, these terms are often use interchangeably. For the purpose of the current review, *token system* will be used to refer to any token procedure (e.g., token reinforcement, token economy), *token reinforcement* will refer to

token systems that involve the exchange of all tokens each time the exchange-production schedule is met (e.g., token board), and *token economy* will refer to token systems that include the option to accumulate tokens and the differential prices for the various back-up reinforcers. Although the token economy is a prolific and effective behavior modification intervention, the studies that will be discussed in the paper will primarily focus on token reinforcement.

Considerations for Token Systems

Token systems are comprised of six procedural components including the target response, a token that is a conditioned reinforcer, back-up reinforcers, and three interconnected schedules of reinforcement (Ivy et al., 2017). All six of these components are present in any token system. It is important for researchers to describe all six components in a conceptually systematic way. Related to these six components, it is important to identify (a) the appropriate schedules of token reinforcement, (b) the token form (i.e., what token will be used), (c) conditioning procedures (i.e., how tokens will be conditioned with those back-up reinforcers, and (d) token manipulations (i.e., who will be responsible for manipulating the tokens).

Schedules of Token Reinforcement

Token systems can be conceptualized as extended chained and second-order schedules of reinforcement (Hackenberg, 2018). A chained schedule of reinforcement is a schedule combination in which completing schedule A (e.g., a response requirement) produces schedule B and completing schedule B produces a reinforcer (DeLeon et al., 2003). Conversely, in a second order schedule, completion of schedule A is reinforced according to schedule B (DeLeon et al., 2003). DeLeon et al. (2003) described token reinforcement as a higher order schedule in which responding produces tokens on a specified token-production schedule. The exchange of tokens for back-up reinforcers then is produced by another schedule (i.e., the exchange-production

schedule). Just as with simple schedules of reinforcement, behavior maintained by token systems is sensitive to schedule type and contingencies of the various schedules of reinforcement embedded with a token system (Hackenberg, 2009). Token systems consist of multiple component schedules of reinforcement including the token-production schedule, exchange-production schedule, and the token-exchange schedule (Hackenberg, 2018). It is important to be well-versed with the various schedules of reinforcement within a token system prior to arranging a token system in a clinical setting. Additionally, there will be reference to the various schedules throughout this paper; therefore, a brief review of the various schedules is presented below.

Token-Production Schedule

The token-production schedule refers to the contingency for when tokens are delivered (Lagorio & Yanagita, 2015). Research has shown that patterns of responding for token production are similar to the patterns of responding observed for primary reinforcers (Lagorio & Yanagita, 2015). Malagodi (1967 a, b, c) evaluated the effects of various schedules of token production on response patterns with rats. They evaluated the response rates under FR 1, FR 20, and VI 1-min schedules of reinforcement. Tokens were immediately exchangeable for food. The rats demonstrated response patterns similar to those observed with primary reinforcement. That is, the FR-20 schedule was associated with high rate performance followed by a break in responding immediately after reinforcement, and the VI schedule was associated with slow and steady rates of responding. Overall, findings from basic literature suggest that token-production schedules produce rates of responding similar to that for primary reinforcement.

In practice, fixed ratio (e.g., FR-1) schedules are used commonly, but intermittent schedules of token production may be associated with high rates of responding, and therefore, may be more suitable in application (Lagorio & Yanagita, 2015). Lagorio and Yanagita (2015)

recommended that if a token system is being used to teach new behaviors, then it is important to deliver reinforcement on a continuous schedule. Conversely, if a token system is in place to maintain high levels of a response already in an individual's repertoire, then an intermittent reinforcement schedule may be more appropriate. Thus, practitioners should consider the desired pattern of responding and identify the token-production schedule that may be associated with the pattern of responding most appropriate for the target response.

Exchange-Production Schedule

The second component of token reinforcement is the exchange-production schedule, which refers to how often tokens may be exchanged for back-up reinforcers (Lagorio & Yanagita, 2015). The exchange-production schedule is the most frequently manipulated component of a token economy and has been described as possibly the most important component (Lagorio & Yanagita, 2015). Token boards are often used in clinical practice. Token boards usually have a fixed number of tokens (i.e., the exchange-production schedule) that must be earned before any tokens can be exchanged. This schedule offers advantages for the individual and the therapist as it allows for a clear, visual representation of how much work must be completed before backup reinforcers are available (Lagorio & Yanagita, 2015). However, one disadvantage to FR schedules is that they are often associated with post-reinforcement pausing. For example, Staats et al. (1962) evaluated the efficacy of tokens at maintaining behavior in a reading program. Tokens were effective even when the exchange-production schedule was thinned. However, the researchers reported break–run patterns of responding. Similar patterns have been observed with various other species when an FR exchange-production is used (e.g., Bullock & Hackenberg, 2006; Kelleher, 1956; Webbe & Malagodi, 1978). Additionally, the

duration of pausing has been shown to increase when the exchange-production schedule increases (Kelleher, 1956).

Alternatively, it is possible to use a variable ratio (VR) schedule for the exchange-production schedule. In VR schedules, high response rates produce high reinforcement rates. As with primary reinforcers, the use of VR schedules for the exchange-production schedule has been associated with short post-reinforcement pauses. If a high rate of responding is of particular importance, a clinician may consider using a VR schedule instead of an FR schedule (Ferster & Skinner, 1957). Foster et al. (2001) compared FR and VR exchange-production schedules across a range of values and found higher and more consistent rates of responding under VR schedules than FR schedules, with lower levels of pausing following reinforcement delivery. Despite the many advantages offered by a VR exchange-production schedule, one disadvantage is that there is no clear visual representation indicating the proximity to reinforcement delivery for the individual or the therapist (Lagorio & Yanagita, 2015). An FR exchange-production schedule provides clear guidelines and cues to the therapist to deliver reinforcement. Removing the visual representation of proximity to reinforcement may be associated with more treatment integrity errors committed by therapists as there is no clear indication when tokens should be exchanged and when reinforcement should be delivered. Although visual representation of the proximity to reinforcement may be beneficial, it also may have detrimental effects as it can serve as a powerful discriminative function leading to weaker performance early in the exchange-production schedule (Lagorio & Yanagita, 2015). If the visual representation indicating the proximity to reinforcement delivery were removed—such as with a VR schedule—then the stimulus control aspect of token systems may be interrupted, thereby potentially decreasing the likelihood of observing weaker performance early in the exchange-production schedule.

Research suggests it is more effective to alter exchange-production schedules and to keep the token-production schedules low (Hackenberg, 2018). It is recommended to alter the exchange-production schedule instead of the token-production schedule, because exchange-production price may correspond to magnitude increases in the terminal reinforcers (Kelleher, 1966). Conversely, token-production schedules are not associated with an increase in reinforcement magnitude (Hackenberg, 2018). Clinicians should consider the most appropriate exchange-production schedule depending on the token system in place, why the token system was introduced, and the needs of the client and therapist.

Token-Exchange Schedule

The third component of token reinforcement is the token-exchange schedule, which is the schedule by which tokens are exchanged for back-up reinforcers (i.e., what and how much reinforcement is earned for tokens). This schedule can be conceptualized in two ways (a) the amount of responding needed to exchange the tokens (i.e., effort-based) and (b) the number of tokens that must be expended per unit (i.e., amount based; Lagorio & Yanagita, 2015).

The token-exchange schedule has rarely been manipulated in basic research. A majority of basic research studies on token systems have used an FR-1 token-exchange schedule in which one response removes one token and produces one back-up reinforcer (Lagorio & Yanagita, 2015). Malagodi et al. (1975) evaluated the rate of lever pressing with rats in one of the only basic studies to evaluate the token-exchange schedule. Lever pressing produced a token (a marble) on an FR-20 token-production schedule and exchange opportunities were produced on an FR-6 exchange-production schedule. The token-exchange schedule required fixed amount between 1–6 tokens. The rats responded at a lower rate throughout the whole sequence when more tokens were required to produce one unit of food.

Establishing token-exchange contingencies may depend on whether the client is verbal and if their behavior is rule-governed (Lagorio & Yanagita, 2015). In clinical application, the physical exchange may not even occur (e.g., once the token board is complete, the therapist may remove the token board and delivered the reinforcer). However, if a token economy is used, the token-exchange schedule is manipulated in that the various back-up reinforcers are differentially priced (i.e., some back-up reinforcers require more the exchange of more tokens to acquire the back-up reinforcer).

Token Form

Another consideration when developing a token system is token identification, which involves identifying the stimuli that will serve as tokens. Gillis and Pence (2015) recommended that tokens should be durable, inexpensive, easy to make, and unique. Tokens may be manipulable or non-manipulable, and there are advantages and disadvantages for both forms. Manipulable tokens are small, can be standardized in size and color, are separable from the primary reward, and can be used with a variety of species (Wolf, 1936). Non-manipulable tokens offer many of the same advantages but cannot be stolen like the traditional manipulable tokens. Lagorio and Yanagita (2015) recommended using either non-manipulable tokens or manipulable tokens that are displayed to the individuals but are only manipulated by the therapist so individuals cannot steal tokens from one another. The risk of tokens being stolen is higher in an environment that is supported on a token economy in which multiple individuals are using the same form of token and tokens are accumulated and saved for later use (e.g., prison, inpatient ward) versus a more controlled environment in which all tokens are earned and exchanged immediately (such as with a token board).

One possibility to address these concerns is to use laminated pieces of paper that may be attached to a token board with Velcro. This option creates tokens that are durable, inexpensive, easy to make, and allows for unique tokens. Additionally, these tokens are manipulable. Although there are disadvantages to using manipulable tokens, these risks are reduced if they are used in a controlled setting, particularly if each individual has unique tokens. Another advantage of using tokens that are manipulable is that manipulable tokens may help support the pairing procedure if the participant is responsible for manipulating the tokens (see below for more details).

Back-up Reinforcers

Another consideration when developing a token system is whether tokens are exchanged for a single or several back-up reinforcers. Moher et al. (2008) recommended that tokens should be generalized conditioned reinforcers such that the tokens are exchanged for a variety of reinforcers because responding may maintain even when there is an abolishing operation for one of the back-up reinforcers. Allowing tokens to be exchanged for a variety of goods and services decreases the likelihood of satiation while allowing the individual an opportunity to choose (e.g., a choice between reinforcers). Russell et al. (2018) extended Moher et al. by including a PR schedule to determine reinforcer effectiveness and by including qualitatively different reinforcers (i.e., leisure and edible). Russell et al. evaluated different levels of pre-session exposure to edible items on the effectiveness of tokens exchangeable for (a) both edible and leisure items and (b) just edible items. Russell et al. found that tokens exchangeable for a variety of reinforcers maintained responding more than tokens exchangeable for edible items alone.

Given the literature supporting the use of generalized conditioned reinforcers (e.g., Moher et al., 2008; Russel et al., 2018) and that one of the major benefits of using tokens is that

they can easily function as generalized reinforcers, it is highly recommended that tokens are exchangeable for a choice of multiple back-up reinforcers.

Conditioning Procedures

After clinicians identify which form of tokens will be used and what back-up reinforcers will be exchangeable for tokens, the next step in creating a token system is conditioning the tokens as reinforcers. It is important to condition tokens as reinforcers such that the tokens obtain reinforcing properties. Ivy et al. (2017) reviewed the literature from 2000–2015 to evaluate the extent to which the components of a token system were described adequately in the published literature. Ivy et al. identified 96 articles that met the inclusion criteria. Out of the 96 articles identified, 50 of those described the token conditioning procedure. Further, during their analysis, they identified two primary methods of conditioning tokens as reinforcers. One method consists of directly pairing the tokens with the back-up reinforcer. Tokens can be directly paired with back-up reinforcers two ways.

First, tokens can be simply paired with back-up reinforcers. For example, Smith (1972) conditioned tokens by delivering tokens noncontingently and then allowing the participants to immediately exchange the token for a toy. Smith compared this procedure to delivering another type of token noncontingently, but the token could not be exchanged for a back-up reinforcer. Smith then made the tokens (either paired or unpaired) contingent on pressing one of two buttons. The effects of the previous pairing condition were evaluated across two groups of children. One group of children experienced the tokens that were previously paired, whereas the other group experienced the tokens that were previously unpaired. There was a strong preference across both groups of children for tokens (paired or unpaired). However, in a subsequent extinction condition, a clear difference occurred in which responding was three times higher for

the token alternative compared to the no-token alternative for the group of children in the paired group. There was no difference in responding for the group of children in the unpaired token group.

Second, pairings can be response contingent. For example, DeLeon et al. (2014) conditioned tokens as reinforcers using a response-contingent pairing. DeLeon et al. (2014) conditioned the tokens as reinforcers by starting with a token-exchange requirement of one token. When a token was delivered (contingent on compliance), the therapist opened their hand and waited for the participant to exchange the token independently. When the token was exchanged, the therapist immediately delivered the back-up reinforcer. If the participant did not exchange the token independently, then the therapist used a three-step guided compliance procedure (i.e., verbal, model, physical) to prompt the participant to exchange the token. The requirement for the token exchange was then systemically increased to five tokens and then to 10 tokens after two consecutive sessions with 100% independent token exchange. Hackenberg (2018) discussed these various methods of conditioning tokens as reinforcers and recommended response-contingent pairings as they have been shown to be more effective. In addition to being more effective, response-contingent pairings also have practical benefits, including that the exchange response is an important component of a token reinforcement program.

The second method consists of verbal descriptions of the reinforcement contingency. For example, Self-Brown and Mathews (2010) evaluated the effects of a token system on performance goals for elementary school children. The therapist provided instructions to the participants to condition the tokens as reinforcers (e.g., “you can earn school dollars for completing you math assignments…once a week you can exchange your school dollars for computer time, pens, markers, keychains, note pads, or candy. You must earn at least ten school

dollars in order to purchase an item"). Some research shows an adaptive role of instructions, but other research suggests that rules can impair behavioral sensitivity to the arranged contingencies (Hackenberg, 2018). Hackenberg (2018) suggested that clinicians recognize the complex effects of rules prior to the inclusion of rules or instructions in the conditioning procedures and that rules or instructions should be used with caution.

Limited research has evaluated the most effective methods to pair tokens as conditioned reinforcers. Although there is limited research on how to condition tokens as reinforcers, there are general suggestions on what steps are essential in the process. Lagorio and Yanagita (2015) stated that when conditioning tokens as reinforcers, timing is of the greatest importance (i.e., the immediacy of reinforcer delivery after a token is exchanged). Additionally, Lagorio and Yanagita discussed the importance of pairing tokens in predictive ways (i.e., creating a clear relation between a response and token delivery). Moreover, Hackenberg (2018) provided recommendations that further supported those recommendations by Lagorio and Yanagita. Those recommendations included starting with a FR-1 response requirement and an immediate requirement to exchange the token. The use of an FR-1 response requirement will create a situation in which the tokens are paired in a predictive way (i.e., identifying a clear and low effort token-production and exchange-production schedule to create a strong pairing history). Moreover, Hackenberg (2018) recommended minimizing the time from when a token is delivered and exchanged to when the primary reinforcer is delivered. In summary, it is important to identify effective and efficient conditioning procedures. However, there is currently limited evidence on which method may be the most effective and efficient.

Token Manipulation

Another consideration when arranging a token system is establishing who will be responsible for manipulating the tokens. The tokens can be manipulated (e.g., accumulated and exchanged) by either the client (the one receiving tokens) or the therapist (the one delivering tokens). There are advantages and disadvantages of both options. One advantage of the client being responsible for manipulating the tokens includes the saliency that a token was earned (Leaf et al., 2012). Additionally, if the client is responsible for exchanging the tokens, then the process of the client physically exchanging the tokens might strengthen the pairing of the tokens with the back-up reinforcer (Leaf et al., 2012). However, some disadvantages include that the tokens may become distracting (e.g., client inspects or plays with the tokens), client may learn to delay the onset of the next event by refusing to place the token in the appropriate location, and prompting the placement of the token in the appropriate location may evoke problem behavior. Some advantages to having the therapist manipulate the tokens include that the therapist maintains control of the tokens, the tokens are less likely to be lost or stolen, and it may decrease the likelihood of the tokens becoming problematic (e.g., distracting).

Limited research has directly compared the efficacy of client- versus therapist-manipulation of the tokens. Sleiman et al. (in press) compared the effectiveness of a token system when the participant physically manipulated the tokens to a token system in which the experimenter manipulated the tokens for three participants diagnosed with autism. The experimenters also assessed participant preference for token manipulation. The results showed that response rates for one participant were higher in the experimenter manipulation condition but there was no differentiation for the two other participants. Additionally, two participants preferred the participant manipulation of token condition, whereas the other participant showed

no preference. More research is needed to identify the most appropriate individual to control the tokens. Although it may be idiosyncratic and depend on specific circumstances, there is not sufficient research to reach this conclusion. In addition, it may be beneficial to have a methodology to identify characteristics of the clients and environment that may suggest who would be more appropriate for token manipulation.

Reinforcing Value of Tokens

Given the frequent use of token systems, knowledge about the relative reinforcing value of tokens as compared to the items for which they are exchanged is important (Fiske et al., 2015). Tokens may be relatively more valuable than back-up reinforcers because they are generalized conditioned reinforcers and less sensitive to abolishing operations, or they may be less valuable due to preference fluctuation for (and delayed access to) the back-up reinforcers (Bonfonte et al., 2020). Evaluating the value or potency of tokens after a token system has been arranged would allow maximally effective arrangements of token system components. These components can then be manipulated to increase the efficacy of token systems. Recently, a few investigations have compared the relative value of tokens to the items for which they are exchanged.

Fiske et al. (2020) used a multiple-schedule reinforcer assessment described by Smaby et al. (2007) to evaluate the relative reinforcing efficacy of tokens and primary reinforcement with four children diagnosed with autism. The experimenters compared the rate of task completion (i.e., pointing to one star and then another star on a piece of laminated paper) during rapidly alternating, signaled conditions of extinction, tokens (without back-up reinforcers), yoked FR primary reinforcement, tokens (with back-up reinforcers), and primary reinforcement. All participants had prior experience with the token system in their classroom. Maximum session

length during the extinction condition was 5 min, but session terminated after 1 min of no responding. During the reinforcement components, the sessions were 1 min in duration. Components were conducted in a fixed order and each component was signaled by different colored task material. The researchers conducted presession exposure for a given component prior to the start of each reinforcer component. Component-specific stimuli were delivered contingent upon each response. During the extinction condition, no programmed consequences were delivered. An extinction component was conducted prior to each reinforcement component. During the tokens without back-up reinforcement component, the therapist delivered tokens (the same tokens as used during the tokens with back-up reinforcement component) contingent upon each task response. The therapist removed the tokens from the board after the participants earned all the tokens and allowed the student to continue to engage in the target task. The session time was paused during the token delivery and token exchange to equate the amount of time the participant was able to respond across all conditions. During the yoked FR condition, the therapist delivered access to a bin of highly preferred items for 10 s after the participant completed the number of responses equal to the number of tokens on their token board. As in the tokens without back-up reinforcement component, the session time was paused when the participant engaged with the reinforcers. During the tokens with back-up reinforcement component, the procedures were identical to the token without back-up reinforcement component except, that the participant exchanged their tokens for access to 10 s of engagement with the bin of preferred items. The session time was paused during token and reinforcer delivery. Finally, during the primary reinforcement component, the therapist delivered 10 s of access to the bin of preferred items on an FR-1 schedule. The session time was paused during reinforcer delivery. Results suggested that two participants responded at a similar rate across both the tokens with

back-up reinforcement and primary reinforcement conditions. Conversely, the other two participants engaged in lower rates of responding in the tokens with back-up reinforcement component compared to the primary reinforcement component. All participants engaged in low rates of responding across the extinction and tokens without back-up reinforcement components. Additionally, three of the participants engaged in higher rates of responding during the token with back-up reinforcement component compared to the yoked FR component. Collectively, the results suggest that paired tokens functioned as reinforcers for all participants, but token systems may not be as effective as primary reinforcement for all individuals. Further, the delivery of reinforcement on a continuous schedule may be more effective for some individuals. One limitation that Fiske et al. (2020) noted was that they did not control for the potential effects of reinforcement magnitude. That is, reinforcer magnitude was likely greater in the primary reinforcement component because reinforcers were delivered on an FR-1 schedule, yet the magnitude of each reinforcer delivery across all reinforcement conditions was the same (10-s access). Regardless, Fiske et al. (2020) offers clinicians a method (i.e., multiple-schedule reinforcer assessment) to quickly evaluate the relative effectiveness of token reinforcement.

Bonfonte et al. (2020) used a progressive ratio (PR) reinforcement schedule to evaluate the relative efficacy of tokens with two young men diagnosed with autism. However, they first assessed whether novel tokens (i.e., participants had no prior token system history) had been established as conditioned reinforcers. Specifically, the experimenters compared a token condition to a tandem condition. In the token condition, all reinforcers were kept out of sight, the therapist delivered tokens on an FR-5 token-production schedule, and there was no set exchange-production schedule (i.e., the participant could earn unlimited tokens). The therapist delivered a 1:1 exchange per token (token-exchange schedule) in which the participant could choose

between the pre-identified edible items after a 1-min delay at the conclusion of the session. The tandem condition was identical to the token condition, except that no tokens were delivered. Both participants responded at higher rates during the token condition as compared to the tandem condition, confirming that the tokens functioned as conditioned reinforcers. Subsequently, the experimenters used PR schedules to compare the efficacy of tokens (exchangeable for edible items) to high- and low-preference edibles used as primary reinforcers. The therapist stated, "you can do work for [reinforcer] or hang out" prior to the start of session. Condition-specific stimuli were in sight throughout all sessions. The PR schedule began with an FR 2 and doubled after completion of each component (FR 2, 4, 8, etc.). There was no limit on how many tokens/reinforcers could be earned. During the high-preference edible condition, participants earned a high-preference edible contingent on each PR step completed. The low-preference edible condition was identical to the high-preference edible condition except a low-preference edible was delivered. The token condition was identical to the high-preference edible condition except a token was delivered each time a PR step was met. The participant could exchange the tokens on a 1:1 ratio for a choice of an array of edible items after a 1-min delay at the conclusion of the session. The researchers found that for both participants, response rates were highest during the high-preference primary reinforcement condition. More specifically, one participant engaged in high levels of responding during the high-preference edible condition and moderate levels of responding in the low-preference edible and token condition. The other participant engaged in variable levels of responding across all conditions but slightly higher levels of responding during the high-preference edible condition. These results suggest that high-preference primary reinforcement functions as a potent reinforcer and produces high levels of responding, whereas tokens produced levels of responding similar to those observed for the less

preferred items, but that tokens still functioned as reinforcers. Although tokens were exchangeable for a variety of reinforcers, they were not as effective as primary reinforcement.

Fiske et al. (2015) also evaluated token reinforcement effectiveness by using PR schedules, similar to Bonfonte et al. (2020). Specifically, Fiske et al. compared the effects of paired tokens, primary reinforcers, and unpaired tokens on the number of academic responses completed by two children diagnosed with autism. However, unlike Bonfonte et al., both participants had prior experience with the token system for one and five years, respectively. The therapist conducted multiple-stimulus-without-replacement (MSWO) preference assessments (DeLeon & Iwata, 1996) before and during (i.e., after a reinforcer was delivered) the paired token and primary reinforcement sessions. The experimenters used a PR schedule of reinforcement (with schedule requirements of 1, 2, 3, 4, 6, 8, 10, 15, 20, 30, 40, 50, 60, 70, 80) during the reinforcer assessment to identify the reinforcing value of the various conditions. The therapist delivered condition-specific stimuli (i.e., paired token, primary reinforcement, unpaired token) after the completion of each PR requirement. During baseline, the therapist instructed the participants to complete a task. Contingent upon meeting the PR schedule, no programmed consequences were delivered. During the paired token condition, the therapist instructed the participants to complete a task to earn a token that could be exchanged for a back-up reinforcer. The therapist delivered a token (i.e., a penny) contingent on meeting the PR requirement. The tokens in the paired token condition were already part of an existing token system used within the participant's everyday skill acquisition programs. The participants traded tokens for back-up reinforcers (i.e., small pieces of edible items) when the exchange-production schedule was met. During the primary reinforcement condition, the therapist instructed the participants to complete a task to earn the reinforcer (i.e., one small piece of an edible item). A reinforcer was delivered

contingent on meeting the PR requirement. During the unpaired token condition, the therapist instructed the participants to complete a task to earn tokens (i.e., smiley face tokens). The therapist delivered an unpaired token contingent on meeting the PR requirement. The participants had no prior history with the tokens delivered in the unpaired token condition. The tokens were not exchangeable for back-up reinforcers when the exchange-production schedule was met. The results showed for both participants that responding was variable during the paired token condition, stable during the primary reinforcement condition, and low during the unpaired token condition. The authors concluded that token systems may be as effective as direct reinforcement, and both may be variably reinforcing across time (sessions). These findings suggest that paired tokens and primary reinforcement may be similarly effective. However, primary reinforcement may produce more consistent levels of responding. Further, token effectiveness is dependent on frequent identification of potent back-up reinforcers. Finally, as with primary reinforcement, tokens are susceptible to satiation effects.

However, the findings of the Fiske et al. (2015) study are limited in several ways. First, the participants had relatively lengthy (i.e., one and five years) histories with the token systems prior to the study, and the authors noted that the method used to initially established the tokens as conditioned reinforcers was not known. The lack of detail regarding the conditioning procedures makes it difficult to conduct technological replications and decreases the ability to detect procedural information that could be critical for drawing conclusions about relative token value. Further, the effects of reinforcement history on responding maintained by conditioned reinforcers is a relatively understudied area, despite widespread applied use of conditioned reinforcers such as tokens (St. Peter Pipkin & Vollmer, 2009). Second, Fiske et al. (2015) conducted their analysis with only two participants, both of whom were diagnosed with autism. Therefore, the

generality of the results is unknown. Token systems are used across a wide variety of populations. Therefore, when conducting an evaluation of token reinforcement effectiveness, it is important to assess the generality of the finding across relevant populations. Finally, reinforcer magnitude differed across the primary reinforcement and token reinforcement conditions. During the primary reinforcement condition, the therapist delivered one piece of the primary reinforcer when a PR schedule requirement was completed. During the paired token condition, the therapist delivered one token when a PR schedule requirement was completed. One piece of the primary reinforcer was then delivered when the exchange-production schedule requirement was completed. This arrangement is problematic because a higher magnitude of reinforcement was delivered in the primary reinforcement condition as compared to the paired token condition. For example, if the token board contained seven tokens, one reinforcer was delivered contingent upon token exchange. In comparison, for the same number of tasks completed, seven reinforcers would have been delivered in the primary reinforcement condition. Reinforcer magnitude has been shown to influence reinforcer value (e.g., Catania, 1963; Hoch et al., 2002; Trosclair-Lasserre et al., 2008), and therefore, may have influenced the results of the study. A more-controlled reinforcer assessment of primary and conditioned reinforcement arrangements would equate reinforcer magnitude.

The results reported by Fiske et al. (2015) differ from those reported by Bonfonte et al. (2020). Fiske et al. (2015) found that the tokens and primary reinforcers produced similar reinforcement effects; although, the primary condition produced more consistent responding. In contrast, Bonfonte et al. found that primary reinforcement was consistently more effective than token reinforcement. There are many different components of a token system, and the steps involved in creating a token system may account for these differences. Various aspects of the

token system arrangement can be manipulated to increase the efficacy of token reinforcement or to further assess the differential effects of token reinforcement in comparison to primary reinforcement. It is important to identify methods to increase the value of tokens especially when delivering primary reinforcement on a dense schedule is not feasible. Further, it is critical to have a strong understanding of the differences and relations between primary reinforcement and paired tokens. This information could lead to improving the application of token systems. Finally, it is important to identify various procedural aspects that could be manipulated when problem solving issues within a token system.

Purpose

The purpose of the current study was to conduct a systematic replication of Fiske et al. (2015) to extend the behavior analytic literature on token reinforcement in applied settings. Specifically, we addressed several of the limitations of Fiske et al. (2015) by (a) including specific conditioning procedures and creating a controlled history of reinforcement with the token system, (b) including participants with and without disabilities to extend the generality of the findings, and (c) equating the magnitude of reinforcement across the primary and paired token conditions. The reinforcing value of tokens was evaluated by comparing the efficacy of primary reinforcement, paired tokens, and unpaired tokens on the level of task completion. A follow-up study was designed to further extend Fiske et al. (2015) and the current study. However, the follow-up study was disrupted by the COVID-19 pandemic. Therefore, the limitations of the current study are discussed in detail in the discussion section and the methodology of the follow-up study is described in Appendix D.

Method

Participants

Six typically-developing young children between the ages of 2 and 5 who attended a university-based preschool and two young children diagnosed with autism between the ages of 4 and 5 who attended a university-based early intensive behavioral intervention program participated in the study. Kenda was a 3-year-old typically-developing female. Lucy was a 3-year-old typically-developing female. Mark was a 4-year-old typically-developing male. Larry was a 4-year-old typically-developing male. Sal was a 3-year-old typically developing male. Molly was a 3-year-old typically-developing female. Austin was a 5-year-old male diagnosed with autism spectrum disorder. Matilda was a 4-year-old female diagnosed with autism spectrum disorder.

The Human Research Protection Program at the University of Kansas approved this project. All participants' parents or guardians provided informed consent prior to participating in this experiment. Additionally, the experimenters obtained assent from the participants prior to conducting each session. Experimenters asked the participants if they would like to go to research. If the participant refused, no sessions were conducted at that time.

Setting and Materials

Sessions took place in a 3 m by 3 m session room equipped with a one-way window adjacent to one of the preschool classrooms. Data were collected on computers and all sessions were recorded on an iPod located behind the one-way window.

The room was equipped with two chairs and a table and only contained the relevant materials for a given session. Instructional materials and a control item were present across all conditions. Instructional material included one of the following: four sets of 100 laminated color

cards about the size of index cards (i.e., pink, purple, yellow, and green) and four sets of corresponding colored boxes (i.e., empty tissue boxes covered with construction paper to match the colored cards) , a 3.5 in in diameter button press that produces a programmed sound when depressed, or a dowel rod glued to a wooden base and small laminated circular stacking cards with a hole pierced through the middle (such that they could be stacked on the dowel rod). The control item was identified using a free operant preference assessment and consisted of one of the following: a small piano keyboard, coloring materials, a dinosaur, a car, or a book.

We used a variety of edible items identified via caregiver report to include in our preference assessments. The items identified as high-preference items were present in the primary reinforcement and paired token conditions. Finally, three different token boards were used throughout this study. The first token board was used during the token training and consisted of a laminated 8.5 by 11 piece of paper with a square box in the center with a piece of Velcro adhered to the middle and one token which was a small white circular laminated piece of paper with Velcro on the back (see appendix A). The second token board was used during the token training and the paired token condition. This token board was similar to the first token board but consisted of five squares spaced equally across the board and five tokens (small white circular laminated pieces of paper). Additionally, the laminated board was taped to an 8.5 by 11 piece of cardboard to increase the sturdiness and durability of the board (see appendix B). The third token board was used during the unpaired token condition. This token board was identical to the five-token system describe above but consisted of a piece of black paper instead of the white paper (see appendix C). The same white circular tokens were used in conjunction with the black token board.

Measurement, Interobserver Agreement, and Treatment Integrity

Graduate and undergraduate students collected data on BDataPro™ (Bullock et al., 2017)—a data collection software. All data collectors completed training that included observing six videos that increased in the complexity of data collection. The criterion to advance to the next video included scoring each video with at least 90% integrity for each response.

A paired stimulus preference assessment (PSPA) was conducted to identified potential edible items that may function as reinforcers. During the PSPA, observers collected data on selection, consumption, expulsion, and no selection. *Selection* was defined as any instance in which the participant's hand came into contact with one of the edibles for a duration of at least 2 s. *Consumption* was defined as the participant placing one of the edibles past the plane of their lips that was not subsequently expelled. *Expulsion* was defined as the participant expelling the edible past the plane of their lips. *No selection* was defined as the participant verbally refusing the edible or 5 s elapsing from when the experimenter instructed the participant to "pick one" without the participant reaching for an edible.

A multiple stimulus preference assessment (MSWO) was conducted to identified potential reinforcers for two of the participants. Observers collected data on selection, consumption, expulsion, no selection, and the position of the item in the array. *Selection* was defined as any instance in which the participant's hand came into contact with one of the items for a duration of at least 2 s. *Consumption* was defined as the participant placing one of the edibles past the plane of their lips that was not subsequently expelled or manipulation of a non-edible item. *Expulsion* was defined as the participant expelling the edible past the plane of their lips. *No selection* was defined as the participant verbally refusing the item or 5 s elapsing from

when the experimenter instructed the participant to "pick one" without the participant reaching for an item.

Data were collected on task engagement during the free operant preference assessment. *Task engagement* was defined as any manipulation of the item (e.g., moving toy from one side of the table to the other, moving the item back and forth) but did not include simply touching the item for all items with the exception of the book. Engagement with the book was defined as any manipulation of the book or eyes oriented toward the book.

Data were collected on task completion, prompted token placement, independent token placement, prompted token exchange, and independent token exchange during the token training. Data were collected on task completion, independent token exchange, engagement, and request for termination during the reinforcer assessment. Data were also collected on therapist behaviors including token delivery and reinforcer delivery during the token training and the reinforcer assessment. *Task completion* was defined as completion of the task response, which was specific for each task. Card sorting was defined as placing the colored card into the corresponding colored box such that the majority of the card was in the box and releasing it (i.e., a sideways card that sticks out of the top counted as one instance, a card lying on top of the box did not count). Card stacking was defined as placing a card with a hole in the center onto a dowel rod and releasing the card. Button pressing was defined as any instance in which the individual's body came into contact with the button press with enough force for the button to produce the programmed sound. Additionally, during the reinforcer assessment, the experimenters calculated the breakpoint for each session. The breakpoint was calculated by identifying the last successfully completed PR step before the end of the session. *Prompted token placement* was defined as placement of the token on the Velcro strip after a prompt (verbal, model, physical)

was delivered. *Independent token placement* was defined as placement of the token on the Velcro strip in the absence of any prompts. *Prompted token exchange* was defined as placing all of the tokens in the therapist's hand after a prompt was delivered. *Independent token exchange* was defined as independently placing all of the tokens in the therapist's hand in the absence of any prompts. *Engagement* was scored using a duration measure and was defined as manipulation of the control item (did not have to be appropriate manipulation). *Request for termination* was defined as vocally stating or signing all done, or a request to return to class. *Token delivery* was defined as placement of a token on the table in front of the child or in the child's hand. *Reinforcer delivery* was defined as the delivery of the reinforcer choice.

Two observers independently recorded responses during at least 33% of sessions to evaluate interobserver agreement (IOA) across all assessments. During the PSPA, trial-by-trial method was used to calculate IOA. To calculate IOA each session was divided into trials and the number of trials in which the two observers agreed was divided by the total number of trials and that number was multiplied by 100. An agreement was scored if both observers recorded the same response for both presented items (e.g., consumption for Oreo, no selection for Cheeto). IOA was assessed on an average of 44% of trials (range, 33 – 71). Overall, IOA was high across all participants (see Table 1 for participant specific IOA results).

As with the PSPA, the trial-by-trial method was used to calculate IOA for the MSWO. However, IOA was calculated for both selection and position of the item during the MSWO. IOA was assessed on an average of 55% of trials (range, 33 – 100). Overall, IOA was high across all participants (see Table 2 for participant specific IOA results).

During the free operant preference assessment, the interval-by-interval method (Mudford et al., 2009) was used to assess IOA for all responses. To calculate IOA each session was divided

into 10-s intervals and the number of intervals in which the two observers agreed was divided by the total number of intervals and that number was multiplied by 100. An agreement was scored if either a) both observers recorded that a response occurred within a specified interval or b) neither observer recorded a response within an interval. IOA was assessed on an average of 46% of sessions (range, 33 – 67). Overall, IOA was high across all participants (see Table 3 for participant specific IOA results).

During the token training and the reinforcer comparison, the partial agreement within intervals method was used to calculate IOA (Mudford et al., 2009). To calculate IOA each session was divided into 10-s intervals and the smaller number of recorded responses for each interval was divided by the larger number of recorded responses for each interval and that number was multiplied by 100 to obtain a percentage. If neither observer recorded a response within an interval it was scored as an agreement. The percentages obtained for each interval were averaged together. The interval-by-interval method (Mudford et al., 2009) was used to assess IOA for all responses that were scored using a duration measure. To calculate IOA each session was divided into 10-s intervals and the number of intervals in which the two observers agreed was divided by the total number of intervals and that number was multiplied by 100. An agreement was scored if either a) both observers recorded that a response occurred within a specified interval or b) neither observer recorded a response within an interval. During the token training, IOA was assessed on an average of 42% of sessions (range, 35 – 48). Overall, IOA was high across all participants (see Table 4 for participant specific IOA results).

During the reinforcer comparison, IOA was assessed on an average of 45% of sessions (range, 38 – 57). Overall, mean IOA was high across all participants; however, the ranges depict that some IOA percentages were low for some sessions (see Table 5 for participant specific IOA

results). Because a portion of sessions were shorter than 1 min in duration which may artificially increase or decrease the IOA scores, we removed all session that were shorter than 60 s from the total number of sessions (for the purpose of IOA calculations). Additionally, we did not include any sessions with IOA on sessions that were shorter than 60 s in our calculations. Due to removing these sessions, not all conditions have IOA calculated on at least 33% of sessions (range, 25 - 67). However, there are at least 38% of sessions (range, 38 - 57) with IOA for each participant. Additionally, for one participant, no baseline sessions met the criteria to be included in the assessment of IOA (i.e., all baseline sessions were less than 60 s in duration). Overall, mean IOA across all assessments was high providing support to the reliability of the measures (condition specific data available upon request).

During at least 33% of sessions, observers collected data on procedural integrity for token delivery and reinforcer delivery across all conditions during the token training and the reinforcer comparison assessment. During the paired and unpaired token conditions, the criterion for token delivery was the completion of the PR requirement. During the paired token condition, the criterion for reinforcement delivery was the completion of the exchange-production requirement (i.e., FR 1 or FR 5 token) and contingent upon the participant exchanging the tokens. During the primary reinforcement condition, the criterion for reinforcement delivery was the completion of the PR requirement. Errors of omission and commission were calculated for each participant. Errors of omission were not applicable in the baseline condition. Errors of commission for the baseline condition were defined as any instance in which a reinforcer or a token was delivered. Errors of omission for the paired token and the unpaired token condition for token delivery were defined as any instance in which the experimenter did not deliver the token within +/- 1 of the criterion response (e.g., if the criterion for token delivery was 50 responses and a token was

delivered after 49 response, then it would be scored as correct. If the participant responded 52 times before a token was delivered, then it was scored as an error or omission). Errors of omission for the paired token for reinforcer delivery were defined as any instance in which the experimenter did not deliver the reinforcer when the exchange-production requirement was met.

Errors of commission for the paired token and the unpaired token condition involved provision of the token if the criterion response was not emitted prior to the delivery of the token. Errors of commission for the paired token condition for reinforcer delivery involved provision of the reinforcer if the exchange-production style had not been met immediately prior to the delivery of the reinforcer (e.g., the criterion for token delivery was 10 responses, but a token was delivered after the fifth response). Errors of omission for the primary reinforcement condition for reinforcer delivery were defined as any instance in which the experimenter did not deliver the reinforcer within +/- 1 of the criterion response. Errors of commission for the primary reinforcement condition involved provision of the reinforcer if the criterion response was not emitted prior to the delivery of the reinforcer. Tables 6 and 7 depicts the procedural integrity for token training and reinforcer comparison, respectively. Errors of omission were calculated as the mean of correct implementation and errors of commission were calculated as a mean frequency.

During the token training, procedural integrity was assessed on an average of 39% of sessions (range, 35 – 43). Overall, procedural integrity was high across all participants during token training suggesting that the procedures were implemented as described (see Table 6 for participant specific procedural integrity results). During the reinforcer comparison assessment, procedural integrity was assessed on an average of 41% of sessions (range, 36 – 47). Overall, procedural integrity was high across all participants during the reinforcer comparison assessment suggesting that the procedures were implemented as described (see Table 7 for participant

specific procedural integrity results). Although the mean procedural integrity was high across participants and error type, the ranges depict that procedural integrity was low for some sessions. For sessions in which procedural integrity was low, the therapist was retrained by the lead researcher. Additionally, procedural integrity was low for one participant in particular, Molly. This may have been due to the speed at which Molly would engage in the target response while simultaneously requesting to terminate session. Due to this pattern of responding and the difficulty of delivering consequences as described, the therapist had to undergo participant specific training by the lead researcher prior to serving as therapist for Molly to increase the likelihood that the procedures would be implemented as described.

Experimental Design and Procedures

Experimental Design

A multiple probe within a multi-element design was used to demonstrate experimental control during the analysis. Control was demonstrated by establishing differentiated rates of responding during the test condition(s) (i.e., paired token, primary reinforcement, unpaired token) compared to the baseline condition.

Procedures

Paired Stimulus Preference Assessment. A 15-item PSPA, as described by Fisher et al. (1992), was conducted to identify five high-preference edible items to be used as potential reinforcers throughout the study. The PSPA was selected for two reasons. First, we wanted to replicate the Fiske et al. (2015) study, and they used a PSPA to identify preferred item. Second, we included young children and children diagnosed with disabilities who may have difficulty scanning large arrays of items (e.g., 15-items). The items included in the PSPA were identified using a modified reinforcer assessment for individuals with severe disabilities (Fisher et al.,

1996). The modified reinforcer assessment for individuals with severe disabilities was conducted with one of the following: the participant (depending on their expressive language skills), the participants' guardian, supervisor of the classroom in which the participant was assigned, or classroom teacher depending on guardian availability. The participant was allowed to sample and consume each item prior to starting the PSPA. The therapist tacted each item prior to delivering the item to the participant to sample. During the preference assessment, items were presented to the participant in pairs. Each item was pitted against every other item once. To identify if there was a side bias, pairs were presented to the participant in a randomized order and placement. A program was used to determine the randomized order. The data collectors recorded data on the item selected and the position of that item. The data were analyzed to identify if the participant had a side bias. For each trial, the therapist presented the pairs to the participant by tacting each item as they were placed in front of the participant (e.g., “this is a gummy worm and this one is a fruit snack”) and gave the instruction “pick your favorite.” Participant selection resulted in the option to consume the item, the other item was removed, and the next trial began. If the participant tried to select more than one item simultaneously, the therapist blocked the participant’s reach, removed the items, and re-presented the trial. If the participant refused to choose an item, the therapist removed both items and re-presented the trial. If the participant did not select an item again, the trial was scored as no selection for either item, and the therapist moved to the next trial. The five items the participant selected the most often were identified as potentially highly preferred and used for the study as potential reinforcers. If two items were selected the same number of times, the researchers used the item that was selected when the two tied items were pitted against each other.

Multiple-Stimulus Preference Assessment. During each reinforcer delivery, a one trial multiple-stimulus preference assessment (MS; DeLeon & Iwata, 1996) was conducted (i.e., each time a reinforcer was earned, the participant selected the reinforcer). The item selected was immediately delivered to the participant. The edible items included in the MS preference assessment were identified as the top five edible items in the PSPA. We conducted this preference assessment each time the reinforcer was earned to replicate Fiske et al. (2015) and to decrease the likelihood of satiation. During the MS preference assessment, the five items were presented to the participant in an array, and the participant was instructed to "pick your favorite." The participant could then consume that item. If the participant tried to select more than one item simultaneously, the therapist blocked the attempt and re-presented the trial.

Additionally, an MSWO was conducted to identify high-preference stimuli to use as reinforcers during the reinforcer assessment for two of the participants (i.e., Mark and Larry). An MSWO was conducted with Mark because a second reinforcer assessment was conducted three months after the conclusion of the initial reinforcer assessment. Research has found that preferences may shift over time (e.g., Mason et al., 1989; Zhou et al., 2001); therefore, the MSWO was conducted to identify new items to be used during the second reinforcer assessment. Additionally, a second MSWO was conducted for Mark, because we observed an overall decrease in responding. We hypothesized that the items identified as potential reinforcers were no functioning as reinforcers. Mark's guardians requested that we not use any items that contained sugar; however, Mark often requested for sugary item (e.g., chocolate). Therefore, we received permission from guardians to use sugar-free alternatives for common sweets (e.g., sugar free cookie). Therefore, we conducted a new MSWO that included the sugar-free sweets along with some preferred savory items identified during the original preference assessment. Edible

items did not consistently function as reinforcers for Larry; additionally, he often requested to terminate research sessions immediately and requested for tangible items. Therefore, the reinforcer assessment with edible reinforcement was discontinued, and a reinforcer assessment with tangible items was introduced. To identify preferred tangible items, an MSWO was conducted with Larry. For both participants, an MSWO was conducted instead of the PSPA for three reasons (1) to be more efficient with time, (2) both participants had strong vocal-verbal repertoires and could follow multi-step instruction, and (3) both participant could scan large arrays; therefore, it was hypothesized that an MSWO would accurately and reliably identify preferred items. The stimuli included in the MSWO were an assortment of 15 edible or tangible items for Mark and Larry, respectively. The MSWO was conducted three times. The participant was given pre-exposure to each item by allowing the individual to either consume or manipulate each item for 30 s. After pre-session exposure, the therapist instructed the participant to "pick your favorite." The participant then consumed or manipulated the chosen item for 30 s. Next, the therapist rearranged and re-presented the array, instructing the participant to once again "pick your favorite" from the remaining items. This process was repeated until (a) no items remained or (b) the participant refused the remaining item(s) for two consecutive trials. If the participant tried to select more than one item simultaneously, the therapist blocked the participant's reach, removed the items, and re-presented the trial. The items identified as the top five most preferred (i.e., ranked first through fifth) were used during the subsequent reinforcer assessments.

Token Training. Before the start of the assessment, token training (DeLeon et al., 2014) was conducted with each of the participants. The token training was conducted in a changing criterion design, and one to three sessions were conducted per day. The purpose of the token training was two-fold (a) to condition tokens as reinforcers and (b) to train the participants to

independently exchange their tokens to gain access to reinforcement. None of the participants had prior experience with a token board; however, all of the participants, except the two diagnosed with autism, had experience with a response cost token system in which a token was delivered at the start of nap time and, if problem behavior did not occur, the token could be exchanged at the end of a specified criterion for a choice of a preferred item. If problem behavior occurred, the token was removed and the opportunity to earn the reinforcer was lost.

At the start of each token training session, the therapist prompted the participant to sit in the chair, and the therapist sat 90 degrees to the right or left of the participant. For a majority of participants, the task was card sorting (i.e., placing a colored card into the corresponding colored box). We wanted to select a target task that would allow for the participants to practice skills that may be functional or beneficial for the participant. We chose card sorting as the target task because we thought that the skill would be in a majority of the participants repertoire, it was discrete, could be completed quickly, could be arranged as a free operant task that did not involve therapist interaction, and it could occur for the maximum number of possible times (i.e., 399). Additionally, it allowed for the participants to practice matching colors and to practice fine motor skills (i.e., picking up cards with a pincher grasp and maneuvering them into a small hole). Matilda was not observed to have the skills necessary to sort the colored cards; therefore, a new task was chosen. The new task was stacking cards onto a dowel rod. Matilda was observed to emit this task reliably. We chose card stacking as the target task because it was discrete, could be completed quickly, could be arranged as a free operant task that did not involve therapist interaction, and could occur for the maximum number of possible times (i.e., 399). Additionally, it allowed for the Matilda to practice fine motor skills (i.e., place a card with a small hole in the middle through a dowel rod). The selection of a fine motor task was additionally beneficial to

Matilda, because it was reported by the early intervention program that she struggled to complete fine motor tasks. Sessions were terminated after the five token exchanges occurred; therefore, the duration of sessions varied (range, 3 s – 30 min).

Prior to the start of session, the therapist placed the token board in front of the participant and delivered an explanation of the token system (e.g., "When you place the card in the correct box, you will get a token. When you fill your token board you can trade-in your token(s) for a treat"). At the start of the session, the therapist then placed the task in front of the participant, delivered one sorting or stacking card, and instructed the participant to complete the task. The therapist used three-step guided compliance to prompt the participant to complete the task (i.e., place a colored card into the corresponding colored box or stack the cards onto the dowel rod). Three-step guided compliance is a hierarchical prompting strategy in which least-to-most prompting consisting of a verbal, model, and physical prompt is used to guide the participant to engage in the task. The therapist delivered the instruction to complete the task. If the participant complied within 3-5 s, the therapist delivered a token. If the participant did not comply, then the therapist provided a model prompt in which the therapist demonstrated the task while providing a verbal prompt. If the participant complied within 3-5 s, the therapist delivered a token. If the participant did not comply, then the therapist physically guided the participant to complete the response and did not deliver a token. The therapist then instructed the participant to complete the task and the prompting hierarchy reset. The therapist used a prompt-delay procedure consisting of a 0, 2, 5, and 10-s delay to prompt the participant to place the token on the board each time a token was delivered. Initially, the exchange-production schedule requirement was one token and there was only one Velcro spot on the token board (see appendix A). The therapist opened their hand palm up for the participant to exchange the token after the token was placed on the token

board. The therapist used a prompt-delay procedure of a 0, 2, 5, and 10-s delay to prompt the participant to hand over the token. The prompt-delay increased after two consecutive sessions. This process continued until the participant independently exchanged the token on 100% of opportunities for two consecutive sessions. When the participant exchanged the token, the therapist presented the participant with a choice of five high-preference items, and the participant selected one of the items to consume. The requirement for token exchange increased to five tokens after the participant met the mastery criteria and the token board was changed so that it contained five Velcro spots on the token board (see appendix B).

A history with the token board was created after completing the initial token training. The token history condition procedures were identical to those in the final two sessions in the token training (i.e., five token system with a 10-s prompt delay). Sessions consisted of completing five implementations of five task completions (i.e., completion of 5 token boards). Sessions were conducted until 20 sessions were completed. The same task as described during the token training was used when creating a history with the token board.

Free Operant Preference Assessment. It was possible the participants might have engaged in the target response because there was no other activity available during the subsequent reinforcer assessment. Therefore, a free operant preference assessment (Roane et al., 1998) was conducted prior to the start of the reinforcer assessment to identify moderately preferred toys to use as a control task throughout all reinforcer assessment sessions. A free operant preference assessment was conducted instead of an MSWO or a PSPA, because we wanted to identify the duration of item engagement to identify items that that participant would engage with for a period of time but would not spend the entire session engaging with the item. Moderately preferred items were defined as average engagement with the item between 20% -

80% of sessions. If three items met this criterion, the item in the middle was selected. If two items met this criterion, the item with the lesser engagement of the two was selected. Six small and easily transportable toys were selected for assessment during the free operant preference assessment. These toys included: paper and markers, toy dinosaurs, a toy car, a small piano, and a book. Prior to the start of the assessment, the participant was exposed to each item. Sessions were 5 min in duration. All items were arranged on a table at an equal distance from the participant and were presented simultaneously. At the start of the session, the therapist instructed the participant to do whatever they wanted to do. During the session, a therapist was present; however, the therapist did not interact with the participant. No programmed consequences were arranged for item engagement. This assessment was conducted three times. Engagement with each item was averaged across sessions, and the average engagement across sessions was used to identify the moderately preferred item.

Reinforcer Assessment. The purpose of the reinforcer assessment was to identify the reinforcing efficacy of primary reinforcement, paired tokens, and unpaired tokens. The reinforcer assessment was conducted similarly to those described in Fiske et al. (2015). The reinforcer assessment was conducted using a PR schedule—PR 1, 2, 3, 4, 6, 8, 10, 15, 20, 30, 40, 50, 60, 70, 80 (Fiske et al., 2015). The therapist delivered the programmed condition-specific stimuli (i.e., primary reinforcement, paired tokens, unpaired tokens) after the competition of the PR requirement. Sessions varied in duration (range, 3 s – 30 min), and one to five sessions were conducted one to five days per week. Termination criteria included (a) participant communication to be done (e.g., “I want to go back to class”, “all done”) , (b) 1 min with no task completion, (c) completion of the last PR step (PR 80)- chosen based on the PR schedule used in Fiske et al. (2015), or (d) 30 min.

The therapist instructed the participant to sit in the chair and sat 90 degrees to the right or left of the participant. Next, the therapist placed the task and the control item on the table within reach of the participant. At the start of a session, the therapist instructed the participant to engage in the task but also instructed the participant that they could tell the therapist when they were all done. The therapist delivered the primary reinforcer (i.e., edible item) and token by placing the item (i.e., the edible items, tokens) in the participant's hand when the specific criterion was met for each condition.

For all but one participant (Matilda), the task consisted of four colored boxes with corresponding colored cards. A correct response consisted of placing the colored card in the corresponding colored box. If the participant placed the incorrect color in the box, the therapist removed the card from the box and placed it back in the unsorted pile and did not provide any attention. For Matilda, the task consisted of stacking circular cards with a hole pierced through the middle of the card on a wooden dowel rod. The card sorting task was initially attempted with Matilda, but the skill was not in her repertoire; therefore, the task could not be performed quickly or independently. Additionally, for three of the participants (i.e., Mark, Larry, Sal), no reinforcement effect (i.e., no differentiation in any of the conditions compared to baseline) was observed during any of the conditions during the reinforcer assessment. Because no reinforcement effect was observed, a second reinforcer assessment was initiated with a task that did not produce a cumulative product. The use of a task with no cumulative product decreased the likelihood that some aspect of the task (e.g., observing the boxes filling up) controlled the level of responding instead of the programmed consequences. The new task consisted of a button press.

Baseline. The baseline condition was conducted identically to the baseline condition in Fiske et al. (2015). At the start of the session, the therapist instructed the participant to complete the task (e.g., "Sort the cards, but you can let me know when you want to be all done"). No programmed consequences were delivered contingent upon the target response.

Paired Token. The paired token condition was similar to the paired token condition, as described by Fiske et al. (2015), with a few exceptions. The five-token token board used during the token training (Appendix B) and the reinforcers were placed on the table in view of the participant. At the start of the session, the therapist instructed the participant to complete the task to earn tokens that could be exchanged for the back-up reinforcer (e.g., "Sort the cards to earn tokens that you can trade-in for treats, but you can let me know when you want to be all done"). The therapist delivered tokens contingent on the completion of a PR step. Unlike Fiske et al. (2015), a one-trial MS preference assessment was conducted when a reinforcer was earned and five pieces of the selected item (i.e., one for each token) or 1 min of access to the selected item (i.e., 12 s for each token) was delivered. Five pieces were delivered to equate the number of reinforcers earned during the primary reinforcement conditions. The PR requirement increased throughout the course of each session. Specifically, the PR requirement increased after each token delivery. There was no stimulus change when the PR requirement increased. Delivery of the reinforcer reset the token board, and the next PR step was initiated.

Primary Reinforcement. The primary reinforcement condition was conducted similarly to the primary reinforcement condition in Fiske et al. (2015). The reinforcers were placed on the table in view of the participant. At the start of the session, the therapist instructed the participant to complete the task to earn a reinforcer (e.g., "Sort the cards to earn treats, but you can let me know when you want to be all done"). The experimenter delivered a reinforcer contingent on the

completion of a PR step. Unlike Fiske et al. (2015), a one-trial MS preference assessment was conducted when a reinforcer was earned instead of after reinforcer consumption, and one piece of the selected item was delivered. The PR requirement increased throughout the course of each session. Specifically, the PR requirement increased after each reinforcer delivery. There was no stimulus change when the PR requirement increased.

Unpaired Token. The unpaired condition was conducted similarly to the unpaired condition in Fiske et al. (2015). Additionally, the unpaired token condition was identical to the paired token condition, except a different token board (Appendix C) was used and the token were not exchangeable for back-up reinforcers. At the start of the session, the therapist instructed the participant to complete the task to earn tokens (e.g., "Sort the cards to earn tokens, but you can let me know you want to be all done"). The unpaired token board was different from the token board used during the paired token condition. The token board was a black piece of laminated paper. A black token board was used to aid in discrimination. The tokens were identical to the tokens used in the paired token condition. The same tokens were used in both conditions to decrease the likelihood that some aspect of the token (e.g., color) produced an effect on behavior. The unpaired token board was placed on the table in view of the participant. The therapist delivered a token contingent on the completion of a PR step. The PR requirement increased throughout the course of each session. Specifically, the PR requirement increased after each token delivery. There was no stimulus change when the PR requirement increased. After the completion of the token board, the participants handed the therapist the tokens, which reset the token board and initiated the next PR step (i.e., no back-up reinforcers were delivered).

Procedural Modifications. Procedural modifications were made for Larry, Molly, Austin, and Matilda. As mentioned above, because edibles did not function as reinforcers for

Larry, a tangible reinforcer assessment was conducted. However, Larry quickly became satiated with the tangible items and often made requests for items that were available in the preschool classroom. Therefore, before the start of each session, Larry was allowed to select the five items used in the session from the 15 items used in the MSWO; additionally, he was allowed to bring one item from the preschool classroom and could choose to select that item as one of the five items used in the session.

Molly was observed to engage in very low levels of responding across all conditions even when the task response was switched to a button press. Therefore, in attempt to identify more potent reinforcers, we allowed Molly to identify which five items she wanted to have available during session. Prior to each session, we showed Molly all the possible items that we had available and asked her to pick five items to be used in session. We decided to have her choose each time prior to session instead of conducting an MSWO because both participants for whom we conducted preference assessments need additional preference assessments or modifications to identify preferred items. Therefore, we selected a method similar to Larry in which Molly could choose which items to include for each session. However, we increased the number of possible choices compared to Larry to increase the likelihood of identifying items that may function as reinforcers (i.e., there may have been items not selected in the original preference assessment that have be more preferred than the items we selected during the initial PSPA). Additionally, Molly had a strong vocal-verbal repertoire. It was hypothesized that she could scan that various item and accurately communicate her preference.

Austin was observed to engage in near-zero levels of task completion across all phases. Therefore, to increase the likelihood of task completion, the therapist handed Austin one colored card to sort at a time instead of giving access to the bin of colored cards. Austin was not

observed to follow simple one-step instructions reliably. It is possible that that rules at the start of session did not function as a prompt to begin the task. The modified procedures may have served as a prompt for him to engage with the task.

Matilda requested access to the bathroom during a majority of sessions. It was hypothesized that she wanted to leave the session room to gain access to attention. It was hypothesized that she wanted attention, because upon leaving session she would approach other individuals and mand for attention; additionally, a majority of her self-initiations were not followed by eliminations. Therefore, noncontingent attention was delivered every 15 to 30 s throughout session in an attempt to decrease the motivation to leave session. The attention consisted of comments unrelated to her behavior or the task (e.g., "I like your shirt"). Matilda continued to request for the bathroom; therefore, her clinical toileting data were reviewed, and it was identified that, on average, she went to the bathroom every 90 min. Due to the long interresponse interval throughout the day and session blocks being a maximum of 30 min, she was taken to the bathroom at the start of a session block, and all subsequent requests for the bathroom were ignored. Additionally, noncontingent attention was discontinued because it was not effective at decreasing requests for the bathroom.

Results

Figure 1 depicts the results of the edible PSPA for all participants. The asterisk denotes the top preferred items for each participant. The top left panel denotes the data for Kendra. Kendra's top five preferred edible items included Skittles, Peppermint Patties, Smarties, sour punch straws, and M&Ms. These items were selected between 64 - 100% of trials. The top right panel denotes the data for Lucy. Lucy's top five preferred edible items included Peppermint Patties, Oreos, sour punch straws, gummy bears, and M&Ms. Lucy selected these items between

57 - 86% of trials. The second to top left panel denotes the data for Mark. Mark's top five preferred edible items included Cheetos, string cheese, fruit snacks, Cheez-its, and Doritos. These items were selected between 79 – 86% of trials. The second to top right panel denotes the data for Larry. Larry's top five preferred items included Peppermint Patties, Cheetos, pretzels, sour punch straws, and sour worms. These items were selected between 57 – 93% of trials. The second to bottom left panel denotes the data for Sal. Sal's top five preferred edible items included fruit snacks, veggie straws, cheddar popcorn, dried strawberries, and dried mangos. These items were selected between 59 – 100% of trials. The second to bottom right panel denotes the data for Molly. Molly's top five preferred items included gummy bears, popcorn, potato chips, jellybeans, and M&Ms. These items were selected between 71 – 100% of trials. The bottom left panel denotes the data for Austin. Austin's preferred items included veggie straws, cheddar popcorn, fruit snacks, jellybeans, and Oreos. These items were selected between 64 – 79% of trials. The bottom right panel denotes the data for Matilda. Matilda's top five preferred items included Skittles, Cheetos, Doritos, Starburst jellybeans, and popcorn. These items were selected between 71 – 100% of trials.

Figure 2 depicts the results of the edible and tangible MSWO for Mark and Larry, respectively. The top panel denotes the data for Mark's first MSWO. Mark's top five preferred edible items included veggie straws, Doritos, Cheerios, cheddar popcorn, and fruit snacks. The middle panel denotes the data for Mark's second MSWO including sugar-free alternatives to common sweets. Mark's top five preferred edible items included caramel chocolate, chocolate cookie, chocolate wafer, Cheeto, and cheddar popcorn. The bottom panel denotes the data for Larry. Larry's top five preferred tangible items included moon sand, a squishy ball, an electricity ball, a LeapFrog handheld game system, and a light-up spinning toy.

Figure 3 depicts the results of token training for all participants. All participants met the token training criteria (i.e., two consecutive sessions with 100% independent trade-in, with the five-token system, the terminate exchange-productions schedule) in an average of eight sessions (range, 6 to 10). All participants continued to independently exchange their tokens on almost 100% of opportunities during the token history condition.

Figure 4 depicts the results of the free operant preference assessment for all participants. The asterisk denotes the item identified as the moderately preferred item to be used during the reinforcer assessment. The top panel denotes the data for Kendra. The book was identified as a moderately preferred item for Kendra. Therefore, the book was used as the control item during the reinforcer assessment. The top right panel denotes the data for Lucy. Coloring was identified as a moderately preferred item for Lucy. Therefore, coloring was used as the control item during the reinforcer assessment. The second to top left panel denotes the data for Mark. The dinosaur was identified as a moderately preferred item for Mark. Therefore, the dinosaur was used as the control item during the reinforcer assessment. The second to top right panel denotes the data for Larry. The piano was identified as a moderately preferred item for Larry. Therefore, the piano was used as the control item during the reinforcer assessment. The second to bottom left panel denotes the data for Sal. The piano was identified as a moderately preferred item for Sal. Therefore, the piano was used as the control item during the reinforcer assessment. The second to bottom right panel denotes the data for Molly. The piano was identified as a moderately preferred item for Molly. Therefore, the piano was used as the control item during the reinforcer assessment. The bottom left panel denotes the data for Austin. The dinosaur was identified as a moderately preferred item for Austin. Therefore, the dinosaur was used as the control item during the reinforcer assessment. The bottom right panel denotes the data for Matilda. The book

was identified as a moderately preferred item for Matilda. Therefore, the book was used as the control item during the reinforcer assessment.

The results of the reinforcer assessment for Kendra are depicted in Figure 5. For this graph and the subsequent graphs, the grey dotted horizontal lines denote the various break points in the PR schedule. To identify the break point for a given session, the reader should identify the first horizontal line equal to or below the data point for that session. For example, the break point for the first paired condition for Kendra was eight. During the initial baseline phase, Kendra engaged in a high levels of task completion, followed by a steep decrease in task completion. During the reinforcer comparison, Kendra engaged in similar levels of task completion in the paired reinforcement condition and the primary reinforcement condition. During the unpaired and baseline conditions, she engaged in low levels of responding. These results suggest that the primary reinforcement condition and the paired token condition produce similar effects and are more effective than the unpaired token and baseline conditions. However, overall, Kendra engaged in low levels of responding across all conditions. Additionally, this interpretation is further limited by the high levels of responding observed in the baseline phase. Figure 6 depicts the cumulative number of responses for each condition within each phase. For this graph and all subsequent cumulative record graphs, series are scaled to the x-axis rather than sessions. We depicted that data in this fashion to compare slopes and cumulative responses as a function of session exposure (i.e., cumulative number of responses after 1st session of one condition compared to cumulative number of responses after 1st session of the other conditions). Additionally, the number of cumulative responses reset after each phase change (e.g., from baseline to reinforcer comparison). The slope of the paired token and primary reinforcer condition is steeper than that of the unpaired and baseline conditions during the reinforcer

comparison. This analysis supports the interpretation that both primary reinforcement and paired tokens function as reinforcers (producing higher levels of responding relative to the baseline and unpaired token conditions in the reinforcer comparison phase) and that there was no clear difference between the primary and paired token conditions.

The results of the reinforcer assessment for Lucy are depicted in Figure 7. During the initial baseline phase, Lucy engaged in low but variable levels of task completion. During the reinforcer comparison, Lucy's responding was differentiated with higher levels of task completion during the conditions in which edible items were delivered. During the primary reinforcement condition, Lucy engaged in high and stable levels of task completion. During the paired token condition, she engaged in moderate and variable frequencies of task completion. During the unpaired token condition, she engaged in moderate but variable frequencies of task completion; however, responding was lower than that observed during the paired token condition. These results suggest that the primary reinforcement condition produced the most stable levels of responding. Figure 8 depicts the cumulative number of responses across sessions for each condition. The slope of the primary reinforcement condition is steeper than the other conditions. Additionally, we initially observed similar levels of responding during the unpaired and paired token condition, however, as the participant had more exposure to the condition, we observed increased responding in the paired condition which is depicted by the steeper slope. This analysis supports that interpretation that the primary reinforcement condition produced the highest levels of responding, but that paired tokens also function as reinforcers (although not to the same degree).

The results of the reinforcer assessment for Mark are depicted in Figure 9. Initially, the reinforcer comparison was conducted with a card sorting task. During the initial baseline phase,

Mark engaged in moderate and consistent levels of task completion. When the comparison of paired tokens, unpaired tokens, and primary reinforcement assessment was introduced, Mark continued to engage in undifferentiated responding. Due to no observed reinforcement effect, the task was switched to a button press. During the baseline condition, Mark engaged in near-zero levels of task completion. During the reinforcer comparison, Mark initially engaged in high levels of responding, followed by a steep decrease in responding. With the introduction of new reinforcers, Mark engaged in differentiated responding with higher levels of responding in the primary and paired condition. During the unpaired and baseline condition, Mark engaged in near-zero levels of responding. These results suggest that the primary reinforcement condition and the paired token condition produce similar effects and are more effective than the unpaired tokens. Figure 10 depicts the cumulative number of responses across sessions for each condition. During the first reinforcer comparison (when the card sorting task was used), the slope of the various conditions was very similar. During the second reinforcer comparison, the slope was the steepest during the paired token and the primary reinforcement conditions. Additionally, we initially observed similar levels of responding during the unpaired and paired token condition, however, as the participant had more exposure to the conditions, we observed increased responding in the paired condition which is depicted by the steeper slope. This analysis supports that interpretation that the paired tokens and primary reinforcement function as reinforcers. Moreover, that both conditions were equally as effective.

Results of the reinforcer assessment for Larry are depicted in Figure 11. Initially, the reinforcer assessment was conducted with edible reinforcement. During the initial baseline phase, Larry engaged in near zero levels of task completion. When the reinforcer comparison was introduced, Larry engaged in variable and undifferentiated levels of responding. Upon

conclusion of the sessions, Larry made requests for tangible items located in the preschool classroom. Due to no observed reinforcement effect and participant requests for tangible items, another reinforcer assessment was conducted with tangible items as the programmed reinforcement. During the baseline condition, Larry engaged in near-zero levels of task completion. During the reinforcer comparison, Larry engaged in high levels of responding during the primary reinforcement and paired token conditions, followed by a steep decrease in responding. During the unpaired token and baseline conditions, Larry engaged in zero task completions. Larry continued to make requests for tangible items available in the preschool classroom. It was hypothesized that Larry's preference had shifted from the original items identified in the MSWO; therefore, prior to each session, a multiple stimulus preference assessment was conducted. During the multiple stimulus preference assessment, Larry picked which five items would be used in the current session. Additionally, due to Larry's requests for the items in the classroom, Larry was able to bring an item from the classroom to research sessions and could choose that item as one of the five items used in session. With the introduction of the MS preference assessment prior to the start of session, slightly differentiated levels of responding were observed. Larry engaged in higher levels of task completion during the conditions in which reinforcement was delivered. During the primary reinforcement condition, Larry engaged in moderate and stable levels of task completion. During the paired token condition, he engaged in moderate but variable frequencies of task completion. During the unpaired token and baseline conditions, he engaged in near-zero levels of task completion. These results suggest that the primary reinforcement condition produced the most stable levels of responding, but that paired tokens also function as reinforcers. Figure 12 depicts the cumulative number of responses across sessions for each condition. During the first reinforcer comparison

(when edible reinforcers were used), the slope of the various conditions were shallow. During the second reinforcer comparison (when tangible items were used), the slope was the steepest during the primary reinforcement conditions; however, responding decreased over time. Once the preference assessment was added the slope of the primary reinforcement condition was the steepest followed by the paired token condition. This analysis supports that interpretation that the primary reinforcement condition produced the highest levels of responding, but that paired tokens also function as reinforcers (although not to the same degree).

The results of the reinforcer assessment for Sal are depicted in Figure 13. Initially, the reinforcer assessment was conducted with a card sorting task. During the initial baseline phase, Sal engaged in near-zero levels of task completion. When the comparison of paired tokens, unpaired tokens, and primary reinforcement assessment was introduced, Sal initially engaged in elevated rates of responding during the paired token condition compared to the unpaired token, primary reinforcement, and baseline conditions; however, responding across all conditions decreased to near-zero levels. Due to no observed reinforcement effect, the task was switched to a button press. During the baseline condition, Sal engaged in near-zero levels of task completion. During the reinforcer comparison, Sal engaged in high levels of responding during the primary reinforcement and paired token condition and low levels of responding during the unpaired token and baseline conditions. Sal engaged in the highest levels of responding in the primary condition. These results suggest that the primary reinforcement condition and the paired token condition produce similar effects, but the primary condition produced the highest levels of responding. Figure 14 depicts the cumulative number of responses across sessions for each condition. During the first reinforcer comparison (when the card sorting task was used), the slopes of the various conditions were shallow. During the second reinforcer comparison (when

the button press was used), the slope was the steepest during the primary reinforcement condition followed by the primary reinforcement condition. This analysis supports that interpretation that the primary reinforcement condition produced the highest levels of responding, but that paired tokens also function as reinforcers (although not to the same degree).

The results of the reinforcer assessment for Molly are depicted in Figure 15. Initially, the reinforcer assessment was conducted with a card sorting task. During the initial baseline phase, Molly engaged in low levels of task completion. When the reinforcer assessment was introduced, Molly initially engaged in low levels of responding across all conditions. Due to no observed reinforcement effect, the task was switched to a button press. During the baseline condition, Molly engaged in near-zero levels of task completion. During the reinforcer comparison, Molly initially engaged in high levels of responding during the primary reinforcement and the paired token conditions; however, responding decreased to low levels. Molly engaged in low levels of responding in the unpaired token and baseline conditions compared to the primary and paired token conditions. Due to the decrease in overall levels of responding, a preference assessment was conducted prior to each session in which Molly picked which items were included in session. After the introduction of the preference assessment, Molly continued to engage in low levels of task completion. These results suggest that there was no reinforcement effect; therefore, sessions were discontinued with Molly. Figure 16 depicts the cumulative number of responses across sessions for each condition. Across all assessment the slope of the various conditions was shallow. This analysis supports that interpretation that there was no reinforcement effect.

The results of the reinforcer assessment for Austin are depicted in Figure 17. Initially, the reinforcer assessment was conducted with a bin of cards placed in front of Austin. During the initial baseline phase, Austin engaged in zero instances of task completion. When the reinforcer

assessment was introduced, Austin engaged in low levels of responding during the paired token, unpaired token, primary reinforcement, and baseline conditions. Due to no observed reinforcement effect, the task was modified such that the therapist delivered cards to Austin. During the baseline condition, Austin engaged initially high levels of task completion, followed by a decreasing trend. During the reinforcer comparison, Austin engaged in high but variable levels of responding during the primary reinforcement and the paired token conditions. Additionally, Austin engaged in low levels of responding in the unpaired token and baseline conditions compared to the primary and paired token conditions. These results suggest that primary reinforcement and paired tokens functioned as reinforcers. Figure 18 depicts the cumulative number of responses across sessions for each condition. During the final reinforcer comparison, the slope of the primary reinforcement and paired token conditions were the steepest. This analysis supports that interpretation that primary reinforcement and paired tokens functioned as reinforcers. Moreover, that both conditions were equally as effective.

The results of the reinforcer assessment for Matilda are depicted in Figure 19. During the initial baseline phase, Matilda engaged in near-zero instances of task completion. When the reinforcer assessment was introduced, Matilda engaged in low levels of responding across all conditions. Matilda was observed to mand for the bathroom. The asterisks along the x-axis denote sessions in which Matilda manded for the bathroom. Initially, the therapist honored all requests for the bathroom; however, due to the hypothesis that the mands for the bathroom were maintained by attention, noncontingent attention was added to session. During the baseline condition, Matilda engaged in near-zero instances of task completion. During the reinforcer assessment, differentiated levels of responding were observed in the primary condition compared to the paired, unpaired, and baseline conditions. Additionally, Matilda engaged in high levels of

responding during the paired condition compared to the unpaired and baseline conditions. However, responding decreased to low rates across all sessions. When mands for the bathroom was placed on extinction and noncontingent attention was removed, an increase in responding with high levels of responding during the primary and paired token conditions compared to the baseline and unpaired conditions were observed. These results suggest that primary reinforcement and paired tokens functioned as reinforcers. Figure 20 depicts the cumulative number of responses across sessions for each condition. During the final reinforcer comparison, the slope of the primary reinforcement and paired token conditions were the steepest. This analysis supports that interpretation that primary reinforcement and paired tokens functioned as reinforcers. Moreover, that both conditions were equally as effective.

Table 8 depicts the average break point for each condition during each reinforcer assessment. The average break point from the baseline conditions is only derived from the baseline probes in the reinforcer comparison and does not include the initial baseline phase. These data suggest that for a majority of participants the break points were highest in the paired and primary condition. These results can be seen the clearest in the final reinforcer assessment.

Discussion

Token systems are commonly used in clinical settings (Hackenberg, 2009), but some research has suggested that they are not always effective (Fiske et al., 2015). A systematic replication of Fiske et al. (2015) was conducted to compare the efficacy of primary reinforcement, paired tokens, and unpaired tokens to a baseline condition. The results were similar to those reported by Fiske et al. (2015). That is, for a majority of the participants (7/8), a reinforcement effect was observed with higher rates of task completion in the primary reinforcement and paired token conditions as compared to the unpaired token and baseline

conditions. Within these general findings, three patterns of responding were observed. For four of the eight participants, higher levels of responding were observed in the primary reinforcement and paired token conditions with more consistent or slightly higher levels of responding in the primary condition. For three of the participants, higher levels of responding were observed in the primary reinforcement and paired token condition, with similar levels of responding across those two conditions. For the remaining participant, no reinforcement effect was observed. These results suggest that primary reinforcement was the most effective at maintaining responding, followed by paired tokens. These results provide evidence that tokens are effective due to being conditioned with back-up reinforcers.

The current experiment extended the findings of Fiske et al. (2015) in at least three ways. First, none of our participants had prior experience with token boards, and we included typically-developing children to assess broader generality of the findings. Second, we equated the magnitude of reinforcement across the primary reinforcement and paired token conditions. In Fiske et al. (2015), only one piece of the edible item was delivered contingent upon exchanging the tokens; therefore, more reinforcement was earned in the primary reinforcement condition compared to the paired token condition. It is unknown if the primary reinforcement condition was more effective because the magnitude of reinforcement was higher in the primary reinforcement condition. Therefore, we equated the magnitude of reinforcement across the primary reinforcement and paired token conditions to control for the magnitude of reinforcement across conditions. Specifically, the participant earned one piece of edible item or 12-s access to a preferred item for each token earned. Third, the initial token training procedure was clearly described (and consistent across subjects) to allow for a more controlled experimental arrangement and ease of future replication.

Overall, the results of the study demonstrate that paired tokens functioned as reinforcers for a majority of participants. However, primary reinforcement produced more consistent and persistent responding for a majority of the participants. Additionally, the current findings are consistent with previous findings (e.g., Bonfonte et al., 2020; Fiske et al., 2015). Thus, it may be most advantageous for clinicians to choose primary reinforcement. However, token systems are generally used when it is not practical to deliver primary reinforcement on a dense schedule. These results suggest that tokens are (a) able to function as reinforcers when primary reinforcement is not feasible and (b) effective due to being conditioned with back-up reinforcers.

In the current study, three patterns of responding were observed. For four of the eight participants (Larry, Sal, Austin, Matilda), higher levels of responding in the primary reinforcement and paired token conditions, with more consistent or slightly higher levels of responding in the primary condition, were observed. This pattern of responding is similar to the findings of Bonfonte et al. (2020) who found that primary reinforcement was more effective than paired tokens, but that paired tokens produced a reinforcement effect.

One explanation for primary reinforcement being more consistently effective is due to the inherent delay to reinforcement embedded within the token system (i.e., the time taken to deliver tokens, place the token on the token board, exchange the tokens). Delayed reinforcement generally has been found to be less effective at increasing behavior relative to immediate reinforcement procedures (Weil, 1984). Immediacy can be an influential parameter of reinforcement, as seen in research evaluating impulsivity (i.e., choosing a smaller sooner reward over a larger later reward). Neef et al. (1993) evaluated the interaction between unequal rates of reinforcement and equal versus unequal delays to reinforcer access for three adolescents with special education needs. Results showed that when the delays were unequal, participants

allocated responding toward the response alternative associated with the shorter delay. Therefore, the primary reinforcement condition may be more effective because reinforcement is delivered more immediately relative to the paired token condition.

Related to the inherent delay to reinforcement in the current study, reinforcement was delivered at a higher rate in the primary reinforcement condition relative to the paired token condition. During the primary reinforcement condition, the reinforcer was delivered after the participant met the PR requirement, whereas, in the paired token condition, the token was delivered after the participant met the PR requirement, and the reinforcer was not delivered until the exchange-production schedule was met. Rate of reinforcement is an influential parameter of reinforcement, as can be seen in research involving the matching law. The matching law states that relative rates of responding match relative rates of reinforcement (Herrnstein, 1961). Mace et al. (1994) evaluated different concurrent variable-interval schedules of reinforcement (i.e., 2:1, 6:1, and 12:1) across two sets of available math problems. The results suggest that participants allocated more responding to the math problem associated with higher rates of reinforcement. Taken together, past research demonstrating the effect of rate and immediacy of reinforcement may explain why primary reinforcement was more effective than paired tokens.

Finally, an alternative and unrelated explanation is that primary reinforcement may have been more effective than paired tokens because tokens may function as discriminative stimuli instead of conditioned reinforcers (Hackenberg, 2018). As the schedule of reinforcement is thinned and more responding is needed to meet the exchange-production schedule, the visual representation of the tokens may signal that the proximity to reinforcement is delayed. The discriminative function could lead to weaker performance early in the exchange-production schedule (Lagorio & Yanagita, 2015).

For three of the participants (Kendra, Lucy, Mark) higher levels of responding were observed in the primary reinforcement and paired token conditions, with similar levels of responding between the two condition. One potential explanation for this pattern of responding is that history of reinforcement with the paired token that may have influenced participant responding- strengthen responding during the paired token condition to be similar to that as primary reinforcement.

Alternatively, the change in magnitude during the paired token condition may have increased the efficacy of the paired tokens. Research suggests that, for some reinforcers, accumulated access to reinforcement may be more effective than distributed reinforcement that is delivered more frequently (DeLeon et al., 2014; Fienup et al., 2011). However, the research on effects of accumulated edible reinforcement is mixed (DeLeon et al., 2014).

Finally, although there is less evidence to support this explanation, it is possible that earning a token may function as a commitment response for some participants which could explain the high levels of responding in the paired token condition. Skinner (1953) stated that a commitment to a course of action is a form of self-control. Once a token is earned, the participant may continue to respond until the tokens are exchanged; therefore, serving as a commitment response. A retrospective analysis could be conducted to identify the point at which participants discontinued responding with a token system (i.e., how many tokens, if any, had been earned for a given token board prior to meeting the session termination criteria) compared to how many responses were emitted with the final PR set in the primary reinforcement. It would be interesting assess whether participants are likely to stop responding immediately after the reinforcer was delivered or if participants continued to respond until responding functionally underwent extinction.

For the remaining participant, Molly, no reinforcement effect was observed. Additionally, this same pattern of responding was observed for other participants at various points during the assessment. There are several possible explanations for this pattern of responding. First, it is possible that the items identified as putative reinforcers did not function as reinforcers. Second, it is possible that activities outside of the programmed sessions were more potent reinforcers than the items selected for use in session. For example, when Molly terminated session, she would immediately request for one of the other children in the classroom. Anecdotally, these two children were often seen playing together and interacting together. Molly also would request that this other child come to session with her or that she did not want to come to session because she wanted to play with this other child. Therefore, it possible that these extraneous variables affected the results of the reinforcer comparison. Additionally, Molly initially agreed to come session almost every time assent was requested. However, as the study continued, she often refused to come to session or would tell the therapist "maybe later." Initially, we attempted to provide reinforcement for children participating in research (an option to go to a room full snacks and toys, the participant was then allowed to select on edible item that was not one of the items reserved for session or play with a toy); however, participants would immediately terminate session and request to go to the "treat room". Therefore, we discontinued providing additional reinforcement after the conclusion of sessions and increased the quality of attention being delivered prior to and after session in attempt to increase the quality of research sessions.

When interpreting the results of the current study, several considerations should be made. First, it is important to consider the time the individual spent consuming the reinforcer. Consumption of the reinforcers could have competed with the participant engaging in the task response. Additionally, consumption time could only influence the duration of two of the

conditions (i.e., primary reinforcement, paired token) as those are the only two conditions in which the reinforcer was available. Additionally, a larger magnitude of reinforcement was delivered during the paired token condition at a given time which may have increase the consumption time after a reinforcer delivery. The consumption time could influence the duration of session decreasing the rate of task completion. However, we analyzed the data as a frequency measure such that the duration of the session did not influence the visual analysis of the data. Additionally, consumption time could influence the termination of session. The session termination criteria included 1 min with no responding toward the target task. To ensure that the session did not terminate due to the time spent consuming the items, the 1-min timer for session termination did not start until the client finished consuming the reinforcers. Although we did not anecdotally notice consumption interfering with responding, we did not directly measure consumption time, nor did we collect data on if consumption time interfered with responding. To control for this potential limitation, we could have collected data on consumption time and removed that time from the total session duration.

Another consideration is that we identified a couple participants (i.e., Kendra, Molly) who engaged in high levels of responding in the initial baseline phase as compared to responding during the reinforcer assessment (including the conditions involving reinforcement). One explanation for this pattern of responding is behavioral contrast. Behavioral contrast is defined as an inverse relation between the rate of a response occurring during one component of a multiple schedule and the conditions of reinforcement in another condition (McSweeny & Norman, 1979). A decrease in responding in the baseline condition may have occurred after the participant experienced reinforcement delivery during the primary reinforcement and paired token conditions.

Contributions to the Literature

The current study, as well as previous literature (e.g., Bonfonte et al., 2020; Fiske et al., 2015), suggests that paired tokens may function as reinforcers, but they may not be as consistently effective as primary reinforcers. These results have several clinical implications. First, it may be preferable to use direct reinforcement in certain situations (e.g., when a high rate of responding is necessary, when the task may be difficult for the learner, teaching a new skill), whereas token systems may be preferable in other situations. It may be that tokens are more suitable for maintaining lower rates of responding. Second, paired tokens do function as reinforcers and can be used in situations in which primary reinforcement would be difficult to deliver. Third, more research is needed to identify methods to increase the efficacy of token reinforcement when primary reinforcement is not feasible.

Token systems are often used in clinical settings where primary reinforcement cannot be delivered on a dense schedule (e.g., school settings, early intervention clinics). Although the current study extends the literature by comparing the reinforcing value of paired tokens, unpaired tokens, and primary reinforcement to comprehensively answer the question of token value, the current experimental arrangement does not directly correspond to token arrangements in a clinical setting. That is, specifically the schedule of reinforcement arranged in the primary reinforcement condition does not allow us to compare paired tokens on the same schedule of reinforcement delivery (i.e., in the current study primary reinforcement is delivered more frequently than in the paired token condition). One of the biggest advantages of token reinforcement is that it may bridge the gap between a response and when reinforcement is delivered (Hackenberg, 2009). This advantage is especially important in clinical settings (e.g., classrooms) where it may not feasible to deliver reinforcement on a dense schedule (Fisher et al.,

2000). The current study could be extended by comparing token reinforcement to primary reinforcement in which primary reinforcement is delivered on the same schedule as the exchange-production schedule. This comparison may more directly align with the arrangement in a clinical setting. Further research could also extend the current literature by comparing primary reinforcement and paired token on skill acquisition targets. The current study, as well as Bonfonte et al. (2020) and Fiske et al. (2015), used skills that were already in the participants repertoire to compare the level of responding across the various conditions. More research is needed to compare the rate of skill acquisition, especially given that token reinforcement is often used in early intervention programs.

The current study was translational in nature. Translational research is particularly well suited to answer research questions about the underlying behavioral processes within an intervention (Mace & Critchfield, 2010). The aim was to investigate fundamental elements of token reinforcement systems to better inform token-system development in clinical contexts. Overall, results suggest that token systems can be variably reinforcing. This assessment may allow clinicians to identify the reinforcing value of tokens and to identify when an issue with the token system arises. This methodology of comparing paired tokens to primary reinforcement could be used to assess various modifications to the token system until an effective and efficient token system is created.

Limitations

The current study has several limitations across various levels of interpretation. First, individualized procedural modifications were necessary for six of the eight participants. For three of the participants (i.e., Mark, Sal, Molly), we did not initially observe a strong reinforcement effect; therefore, we changed the task to require a less effortful response that did

not result in a cumulated product (i.e., button press). For two of those three participants (i.e., Sal, Molly), a reinforcement effect still was not observed or did not maintain across time; therefore, additional preference assessments were conducted. For Larry, we used tangible reinforcers because we did not observe a reinforcement effect with edible reinforcers. However, responding did not maintain, so we added an additional preference assessment prior to session. Matilda's procedures also required extensive modifications. We changed the task because the skills required to complete the initial task were not in her repertoire. Due to the high rate of Matilda's mands for the bathroom, additional modifications were made, including the addition of noncontingent attention to decrease escape-maintained requests. However, noncontingent attention did not produce a lasting effect on behavior. Therefore, another manipulation was made in which mands for the bathroom no longer resulted in termination of the session and noncontingent attention was discontinued. Finally, we modified Austin's response arrangement because it appeared that he was not attending to the materials. Instead of switching the task to a button press, we modified the card sorting task such that the therapist delivered one card at a time making it such that the task was no longer a free operant. These individual modifications are a concern because they decrease the internal validity of the study, thereby decreasing the level of experimental control. The internal validity is further limited because the changes varied across participants. The results of the study would be more conclusive if the procedures were identical across all participants and modifications, if necessary, were conducted in a systematic fashion. In addition, the results would be more conclusive if reinforcer effects were observed without the need for modifications.

Second, token training was conducted with the same task used during the reinforcer comparison. The pairing procedure could have altered the results of the current study as the

primary reinforcement condition did not have the same history of reinforcement as the paired token condition. Research has shown that the results of assessments and interventions are influenced by the participants reinforcement history (St. Peter Pipkin & Vollmer, 2009). For example, Weiner (1969) compared the rate of responding during an FI schedule of reinforcement after the participants were exposed to one of three history schedules: FR 40, differential reinforcement of low rate (DRL) 20 s, or DRL 20 s followed by FR 40. Participants who experienced the FR-40 schedule only responded at the highest rate during the FI schedule of reinforcement. The results of the Weiner study suggest the participants' history had an effect on the observed results. It is possible that the paired token condition produced the observed levels of responding in part due to the history of reinforcement created during the pairing procedure. The limitation could have been addressed if the task used during token training was different from the task used during the reinforcer comparison.

Third, the method used to create a history of reinforcement with the token system was limited. We conducted a condition in which we attempted to strengthen the history with tokens after participants learned how to independently exchange their tokens. This history condition was conducted for two reasons. First, we wanted participants to be fluid and independent in their token exchanges. We wanted to decrease the likelihood of observing low levels of responding because the participant did not meet the token-production or exchange-production schedules. Second, as the current study was a systematic replication of Fiske et al. (2015) and both participants in Fiske et al. (2015) had a long history with tokens (i.e., 1 year and 5 years), we wanted to contrive a similar history with paired tokens. Moreover, we used the same task from the reinforcer comparison to create the history. However, as with token training, the history

condition could have altered the results of the current study as the primary reinforcement condition did not have the same history of reinforcement as the paired token condition.

Although it is important to create a history with the token board, there are two alternatives that could have mitigated the limitation. One option would have been to create a history with a task that was different from the one used during the reinforcer comparison. Alternatively, we could have created a history with the paired token and the primary reinforcement condition. Either of these modifications would decrease the likelihood that the paired token condition may have produced higher levels of responding due to greater exposure to paired tokens producing reinforcement for the targeted task.

A fourth limitation involved the procedural arrangement for creating a history with the paired tokens, specifically the length of the sessions and the duration of the condition. Reinforcement effects may diminish if there is an abolishing operation in effect for the given reinforcer(s). For example, North and Iwata (2005) observed decreased response rates across sessions when seven consecutive sessions were conducted for 7 of 9 participants. It is possible that with the number of sessions and the length of the condition, the participant may have become satiated with the chosen reinforcers. The participants earned 10 edible items each day for 10 days. For a majority of participants, days were consecutive (with the exception of weekends). By reducing the length of session (of the number of completed token boards) or the number of sessions conducted within the token history, we may have decreased the likelihood that the participants became satiated with the reinforcers.

Fifth, with respect to the token training and token history condition, we did not create a history of equating the number of tokens earned to the number of reinforcers delivered. Therefore, the token history procedures differed from the paired token condition in the reinforcer

comparison in multiple ways (i.e., from a FR-1 schedule of token production to a PR schedule as well as the magnitude of reinforcement earned). This potential confounding variable could have been eliminated if we had conducted the token training and the token history with the number of tokens equating the amount of reinforcement earned.

A sixth limitation involves low levels of responding creating difficulty with interpretation of the reinforcer comparison data. Responding was low across all conditions for some of the participants, making the results difficult to interpret. There are a few potential explanations for these patterns of responding. Based on these possible explanations, we could have made potential modifications to increase the likelihood of observing more persistent responding. First, it is possible that some of the items identified as potential reinforcers did not function as reinforcers. For a majority of participants, a preference assessment was conducted only at the start of the reinforcer assessment. However, research has shown that preferences may not be stable for some individuals and thus preference assessments should be conducted frequently, both to reflect changes in preference and to avoid decrements in performance as a function of satiation (Hanley et al., 2006). It is possible that more frequent preference assessments could have increased the efficacy of both the primary reinforcement and paired token conditions. Although we did not conduct frequent preference assessments, a choice between five items was delivered each time the reinforcer was delivered. This was done because research has shown that choice in itself can be a reinforcer (e.g., Ackerlund Brandt et al., 2015; Fenerty & Tiger, 2010; Fisher et al., 1997; Geckeler et al., 2000; Schmidt et al., 2009; Sran & Borrero, 2010; Thompson et al., 1998; Tiger et al., 2006; Tiger et al., 2010) and that including multiple items may decrease the likelihood of satiation (Moher et al., 2008; Russell et al., 2018). This issue could have been resolved by conducting more frequent preference assessments.

Another potential explanation for the low levels of responding is that the PR requirement increased too quickly causing ratio strain. Ratio strain is defined as a pause in responding due to large ratio sizes or infrequent reinforcement (Catania, 2013). Therefore, it is important to select a PR schedule that increases quickly enough to reveal a difference in response rates while also preventing ratio strain (Roane et al., 2001). More robust effects may have been observed if the PR schedule increased more slowly using PR schedules similar to those as described in Roane et al. (2001).

Finally, it is possible that other items outside of the experimenter's control (e.g., toys, attention in the preschool classrooms) were more valuable than the reinforcer present in session. All participants had the choice to attend research sessions and could terminate those research sessions at any point. Rules stated at the beginning of each session highlighted those contingencies. It is possible that we may been better able to evaluate the level of responding under the various conditions if the participants were not able to terminate session immediately. If the participant discontinued responding, one of the termination criteria would still be met (i.e.,1 min without responding to the task response) and the participant could return to class. Elimination of the termination criterion of the participant being able to request to be done with session, could have decreased the likelihood that sessions were terminated immediately and increase the likelihood of observing responding. This increase in session length may have increased the likelihood that we could assess the reinforcing value of the items in session.

Another limitation that is related to the reinforcer comparison was the target task that was chosen. We chose tasks that were discrete, repeatable, arranged as a free operant, and had some clinical relevance. The card sorting task was chosen because it was discrete, could occur quickly, and created opportunities for the participants to practice skills that will be important for them in

kindergarten (i.e., sorting, color identification, fine motor skills). However, this task left a permanent product, and it had discriminative properties to how much work could be completed. Further, the target task had to be altered in some fashion for five of the eight participants. Button pressing was the second task that was chosen for three of the five participants for which the task was modified. For two of those participants, we observed differentiated responding. Although button pressing is discrete and it can occur quickly, it is not a skill that is important for the targeted population. Therefore, a skill that does not involve a permanent product, but still holds clinical relevance and is able to produce higher levels of responding may have been more appropriate. The button press produced more differentiated responses; however, the response required minimal effort. It is important to identify the efficacy of token reinforcement on responses that will be expected to occur in the natural environment. For example, using an electronic card sorting task that does not create a physical pile such as on a learning application may provide more information on the efficacy of token reinforcement on responding that is more likely to be arranged in a clinical setting. Additionally, a typical arrangement of token systems might include a variety of tasks, some which may be more complex. It is possible that results may have differed if a variety of tasks were used or if the tasks were more difficult.

The token boards chosen for the assessment was another limitation of the reinforcer comparison. The tokens were identical across the unpaired and paired token condition. The only difference was the color of the token board. We initially chose to keep the tokens the same across the two conditions to decrease the likelihood that some variable that was irrelevant to the current experimental condition (e.g., color or shape to the token) produced higher levels of responding. However, choosing tokens and token boards that shared similar properties could have decreased the saliency of the different condition which could produce undifferentiated responding if the

participant does not discriminate between the two conditions. To enhance discrimination, discriminative stimuli could have been added to facilitate differential responding during a multielement design (Conners et al., 2000). For example, if the token boards were extremely different across the two conditions, it may have increased the probability that the token board would be salient. Additionally, we could have included other items to correspond with each condition (e.g., colored table clothes, colored shirts, colored hats, room colors). The addition of these stimuli could increase the probability that some stimulus would be salient which could have aided the participant in discrimination which may have led to quicker differentiated responding.

In the current study, primary reinforcers were delivered more frequently than in the paired token condition. One advantage of using tokens is to bridge the gap between when a response is emitted and when a reinforcer is delivered (Hackenberg, 2009). In the current study, during the primary reinforcement condition, the primary reinforcer was delivered after each PR step, whereas a token was delivered after each PR step in the paired token condition and those tokens could only be exchanged for back-up (primary) reinforcers after every fifth PR step. Thus, reinforcers were delivered more frequently in the primary reinforcement condition. In an attempt to resolve this issue, the magnitude of reinforcement was equated across the two conditions (i.e., five pieces of food were delivered each time the tokens were exchanged). However, this modification does not eliminate the possibility that the primary reinforcement condition was more effective because reinforcement was delivered more frequently.

The discrepancy in reinforcement delivery could be discussed as distributed (i.e., the primary reinforcement condition) versus accumulated (i.e., the paired token condition) reinforcement comparison. Some researchers have shown that some individuals may prefer

accumulated reinforcement, especially when the reinforcer involves an activity that may increase in value with uninterrupted access (DeLeon et al., 2014; Fienup et al., 2011). However, the effects of accumulated reinforcement have not been shown to be as robust with edible reinforcers (DeLeon et al., 2014). Future research could evaluate the value of token reinforcement when the rate of reinforcement delivery is equated between the primary reinforcement and paired token conditions. For example, primary reinforcement could be delivered when the equivalent of the exchange-production schedule is met in the paired token condition, but not when the token-production schedule is met (for the current study that would equate to every 5th PR step). Alternatively, the primary reinforcer could be delivered after each PR step, but the reinforcer would be withheld until the equivalent of the exchange-production schedule is met (for the current study that equate to every 5th PR step).

The limited number of baseline probes was another limitation of the current study. To decrease the total duration of the assessment, we only conducted baseline probes every third series. However, some of the results are difficult to interpret due to the limited amount and infrequent baseline sessions. For example, Molly initially engaged in elevated levels of responding during the second reinforcer comparison; however, responding dropped to low levels across all conditions prior to the first baseline probe being conducted. If a baseline probe had been conducted earlier, it may suggest that there was an initial reinforcement effect. Because no baseline session was conducted then, there was no control condition to which responding could be compared. More frequent baseline sessions may have allowed for easier, more conservative, and more thorough interpretation of the results.

A final limitation included that the participants' responding was variable for many of the participants, which leads to difficult visual interpretation of the results. Additionally, we were

unable to isolate factors responsible for the variability in responding. Results may have been more conclusive if responding was stable across a given condition. This variability in responding may have been due the experimental design. It is possible that carryover or sequence effects influenced the results of the current study. For example, participants may have had difficulty discriminating contingencies between the various conditions. One potential solution is to program condition-specific stimuli to aid in discrimination (Conners et al., 2000). Another potential solution is to use a different experimental design to demonstrate experimental control. For example, a reversal-type design with a phase of several consecutive session in a single condition preceded and followed the baseline condition could have been used. However, such a design may not be feasible due as it would increase the duration of the assessment.

The results of the current study suggest that primary reinforcement and paired tokens are both effective at producing higher levels of task completion than baseline and unpaired tokens. The results of this study highlight the importance of pairing tokens with back-up reinforcers. However, the results of the current study were not robust and there were numerous limitations. Overall, we observed low levels of responding for four of the eight participants. It is critical to have a strong understanding of the differences and relations between primary reinforcement and paired tokens. This information could lead to improving the application of token systems. Moreover, it is important to identify various procedural aspects that could be manipulated when problem solving issues within a token system. Therefore, a follow-up study was designed to replicate and alter various aspects of the experimental arrangement from the current study to evaluate effects resultant of potential differences in responding across the primary reinforcement, paired tokens, unpaired token, and baseline conditions (see appendix D for a description of the methods). We designed the new study to address a number of the limitation of current study by

(1) altering the task that will be used in the token training to be different from that task that will be used in the reinforcer comparison, (2) using the same task that will be use in the reinforcer comparison during the history condition, (3) altering the session termination criteria of the token training such that less reinforcement is earned, (4) adding a primary reinforcement condition to the token training to create an equal history of reinforcement across the primary reinforcement and paired token condition, (5) equating the amount of reinforcement to the number of tokens during the token training, (6) altering the termination criteria of the reinforcer comparison to eliminate the criteria of the participant requesting to terminate session, (8) altering the PR schedule to increase slowly to decrease the likelihood of satiation, (9) altering the target response during the reinforcer comparison to use a task that is more clinical relevant, and (10) changing the token boards to be more salient. We finalized the proposed methods to the follow-up study in the beginning of March 2020. We obtained informed consent forms for two children to participate in the study and began conducting a preference assessment for one of the participants prior to Spring Break. However, the coronavirus began spreading widely across the world creating a pandemic. Due to the pandemic, the rest of the spring and the entire summer term were held virtually. Additionally, the university froze all non-essential research. Therefore, our research was disrupted, and we were unable to conduct the proposed study. We plan to conduct the proposed method once human-subject research is reinstated.

Areas for Future Research

Results of the current project highlight several areas for future research. When designing this study, we needed to identify a method for conditioning tokens as back-up reinforcers. Although there is some literature that provides recommendations for how to pair tokens as reinforcers (Ivy et al., 2017), no studies have directly compared different methods for pairing

tokens with reinforcers. More research is needed to compare various methods of conditioning procedures to identify the most effective method to pair tokens with back-up reinforcers. This information could increase the effectiveness and efficiency of conditioning tokens as reinforcers. Moreover, the optimal method of conditioning tokens as reinforcers may depend on an individual's skill set, so it may be valuable to identify more-effective methods for identifying prerequisite skills most likely to be successful with specific pairing procedures. For example, an individual who can follow multi-step instruction may benefit from rules; whereas, an individual who does not follow instructions may benefit more from a conditioning procedure that does not include rules. Future research could examine whether certain prerequisite skills lead to greater success when conditioning tokens.

Despite the widespread use of tokens, it is not clear which mechanisms are responsible for its efficacy (Hackenberg, 2018). A few potential functions, as discussed by Hackenberg (2018), include that tokens may be reinforcing, tokens may be discriminative stimuli—signaling that reinforcement is forthcoming, or tokens may have an eliciting function. Although there is some basic literature that has evaluated potential mechanisms of token reinforcement, little applied work has contributed to the understanding of mechanisms responsible for its efficacy.

Generally, it is assumed that tokens serve as conditioned reinforcers (Hackenberg, 2018). Tokens may develop reinforcing properties because they are paired with reinforcers. Support for this view comes from tokens increasing and maintaining responding. For example, Wolfe (1936) showed that chimpanzees would work to earn tokens that were exchangeable for food. In contrast, the same chimpanzees would not work for tokens that were not paired with food. These results highlight that tokens may derive their value by being paired with the back-up reinforcer.

Another possible mechanism is that, rather than being conditioned reinforcers, tokens are discriminative stimuli—signaling the upcoming availability of reinforcement. Hackenberg (2018) discussed that in addition to the repeated pairing of tokens and a back-up reinforcer, tokens also occasion token production and exchange and, therefore, are likely to function as discriminative stimuli.

In addition to the reinforcing and discriminative function of tokens, tokens may serve an eliciting function. The delivery of the token, after being paired with unconditioned stimulus (e.g., food), has been shown to produce behavior that appears to be respondent in nature (Hackenberg, 2009). For example, Cowles (1937) evaluated the effects of tokens exchangeable for food delivered contingent on correct responses and unpaired tokens for incorrect responses with chimpanzees. The chimpanzees were observed to engage in consummatory responses (e.g., placing tokens in mouth) with the tokens paired with food. It is possible that the delivery of the paired tokens elicited these consummatory response. These patterns of responding have been reported in other studies as well (e.g., Boakes et al., 1989; Kelleher, 1958; Midgley et al., 1989).

Due to tokens being paired with a back-up reinforcer and that tokens occasion responses that occur in its presence, tokens may have multiple functions (Hackenberg, 2018). When arranging a token system, it is important to take into consideration all of the possible mechanisms in place to arrange the most effective and efficient system. More research is still needed to identify the mechanism of token systems. Better understanding of mechanisms responsible for their efficacy may allow clinicians and researchers to design optimal arrangements of token systems.

Token systems are comprised of multiple components, including the target response, tokens, back-up reinforcers, and the various schedules embedded within a token system (Ivy et

al., 2017). Other considerations include the form of the token, how tokens will be conditioned with back-up reinforcers, and who will be responsible for manipulating the tokens. Research could help to identify optimal components that lead to a token system that is more effective in a given situation. More specifically, researchers could manipulate any of the various dimensions of reinforcement (for the back-up reinforcer or the tokens) including immediacy, magnitude, rate, or quality. For example, future research could evaluate the effects of manipulating the quality of the token by comparing token form (i.e., preferred versus neutral tokens) on the efficacy of token systems.

Token systems may also be added to treatment packages to bridge the gap between a response and the delivery of a reinforcer during reinforcement schedule thinning. However, it is possible that clinicians may overuse token systems. Reinforcement schedule thinning and differential reinforcement alone may be sufficient to increase desirable behavior and decrease problem behavior. However, no research has directly compared reinforcement schedule thinning with and without tokens. An understanding of the efficacy of and preference for reinforcement schedule thinning with and without tokens could lead to a more sophisticated approach toward programming token systems which could produce more robust and durable treatment effects.

Overall, the results of this study suggest that paired tokens function as reinforcers; however, they may not be as potent as primary reinforcement. This study adds to the current literature by furthering the examination of the value of token reinforcement. Token systems are a valuable tool used by many individuals within and outside the field of behavior analysis. Therefore, it is necessary to continue to conduct research to identify the most effective methods of using token systems.

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Tables

Table 1

IOA for the PSPA for All Participants

Participant	Selection Agreement
Kendra	97.14
Lucy	97.73
Mark	97.17
Larry	97.14
Sal	100
Molly	90.70
Austin	91.38
Matilda	97.14

Table 2

IOA for the MSWO for Larry and Mark

	Responses	
Participant	Selection	Position
Larry	100	100
Mark 1	100	93
Mark 2	100	94

Table 3

Mean IOA and range for the Free Operant Preference Assessment

	Engagement											
	Piano		Coloring		Book		Telephone		Dinosaurs		Cars	
Participant	M	Range	M	Range	M	Range	M	Range	M	Range	M	Range
Kendra	86.87	80-93	93.33	90-97	100	100-100	95.00	90-100	100	100-100	95.00	90-100
Lucy	100	100-100	100	100-100	100	100-100	89.46	89-80	100	100-100	100	100-100
Mark	100	100-100	100	100-100	100	100-100	100	100-100	100	100-100	100	100-100
Larry	100	100-100	100	100-100	100	100-100	100	100-100	98.28	97-100	96.55	93-100
Sal	96.70	97-97	100	100-100	100	100-100	100	100-100	100	100-100	100	100-100
Molly	100	100-100	100	100-100	98.50	97-100	98.50	97-100	100	100-100	100	100-100
Austin	100	100-100	93.33	93-93	96.60	97-97	100	100-100	100	100-100	96.60	97-97
Matilda	100	100-100	100	100-100	98.50	97-100	100	100-100	100	100-100	100	100-100

Table 4

Mean IOA and range for Token Training

Ta

	Responses													
	Task Completion		Independent Token Exchange		Prompted Token Exchange		Independent Token Placement		Prompted Token Placement		Token Delivery		Reinforcer Delivery	
Participant	M	Range	M	Range	M	Range	M	Range	M	Range	M	Range	M	Range
Kendra	92.36	78-100	98.00	94-100	99.66	97-100	96.46	94-100	99.69	98-100	97.31	90-100	95.17	88-100
Lucy	92.42	89-100	97.86	93-100	98.35	90-100	92.90	71-100	96.49	79-100	96.32	91-100	95.09	88-100
Mark	96.89	91-100	95.83	81-100	98.01	82-100	93.42	81-100	99.85	98-100	97.20	89-100	96.76	81-100
Larry	97.46	92-100	95.64	78-100	100	100-100	95.64	78-100	97.82	85-100	96.12	85-100	94.40	85-100
Sal	94.66	87-100	96.75	87-100	99.11	89-100	95.76	89-100	100	100-100	96.57	90-100	98.51	86-100
Molly	95.00	77-100	96.44	80-100	98.65	88-100	92.83	70-100	98.41	88-100	96.39	79-100	95.77	86-100
Austin	98.45	93-100	99.56	96-100	99.15	92-100	98.52	93-100	95.79	83-100	94.78	67-100	99.62	95-100
Matilda	96.23	75-100	97.61	95-100	98.01	81-100	92.67	82-100	98.80	90-100	96.32	88-100	99.23	95-100

Table 5

Mean IOA and range for Reinforcer Comparison

	Responses											
	Task Completion		Token Exchange		Request to Terminate		Control Item Engagement		Token Delivery		Reinforcer Delivery	
Participant	M	Range	M	Range	M	Range	M	Range	M	Range	M	Range
Kendra	90.41	65-100	100	100-100	100	100-100	100	100-100	97.81	88-100	97.35	83-100
Lucy	92.36	78-100	97.27	90-100	99.43	94-100	100	100-100	99.01	93-100	97.05	84-100
Mark	94.33	79-100	98.53	75-100	100	100-100	100	100-100	95.90	75-100	96.61	63-100
Larry	96.36	92-100	98.82	89-100	98.62	89.4-100	97.56	78-100	99.30	95-100	99.15	94-100
Sal	96.74	71-100	100	100-100	99.14	78-100	100	100-100	98.54	56-100	99.77	89.5-100
Molly	94.90	77-100	99.74	97-100	100	100-100	97.98	87-100	100	100-100	99.41	87.5-100
Austin	96.23	75-100	99.92	98-100	100	100-100	99.68	94.8-100	99.32	94-100	99.49	97-100
Matilda	96.74	71-100	100	100-100	99.14	78-100	100	100-100	98.54	56-100	99.77	78-100

Table 6

Procedural Integrity for the Token Training

	Errors of Token Omission % Correct		Errors of Reinforcer Omission % Correct		Errors of Token Commission Frequency		Errors of Reinforcer Commission Frequency	
Participant	M	Range	M	Range	M	Range	M	Range
Kendra	100	100-100	100	100-100	0	0-0	0	0-0
Lucy	100	100-100	100	100-100	0	0-0	0	0-0
Mark	100	100-100	98.00	80-100	0	0-0	0	0-0
Larry	100	100-100	100	100-100	0	0-0	0	0-0
Sal	99.60	96-100	100	100-100	0.1	0-1	0	0-0
Molly	100	100-100	100	100-100	0.08	0-1	0.08	0-1
Austin	100	100-100	100	100-100	0	0-0	0	0-0
Matilda	97.78	80-100	100	100-100	0	0-0	0	0-0

Table 7

Procedural Integrity for the Reinforcer Comparison

	Errors of Token Omission % Correct		Errors of Reinforcer Omission % Correct		Errors of Token Commission Frequency		Errors of Reinforcer Commission Frequency	
Participant	M	Range	M	Range	M	Range	M	Range
Kendra	100	100-100	100	100-100	0	0-0	0.15	0-2
Lucy	100	100-100	100	100-100	0.17	0-1	0	0-0
Mark	96.23	82-100	99.17	90-100	0.22	0-4	0.13	0-3
Larry	95.58	67-100	95.83	50-100	0	0-0	0	0-0
Sal	97.17	80-100	97.89	82-100	0.05	0-1	0.05	0-1
Molly	88.30	0-100	90.83	50-100	0.11	0-2	0.21	0-3
Austin	100	100-100	100	100-100	0	0-0	0	0-0
Matilda	98.64	85-100	98.91	88-100	0	0-0	0	0-0

Table 8

Average Break Point for each Condition for each Reinforcer Assessment

	Average Break Point											
	Reinforcer Assessment 1				Reinforcer Assessment 2				Reinforcer Assessment 3			
Participant	Baseline	Paired	Primary	Unpaired	Baseline	Paired	Primary	Unpaired	Baseline	Paired	Primary	Unpaired
Kendra	2.0	3.8	4.0	2.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lucy	3.3	6.2	7.3	4.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mark	N/A	12.5	9.0	9.0	2.5	22.7	13.2	13.6	1.0	14.3	7.2	1.0
Larry	0.5	6.9	2.7	3.6	0.0	6.8	13.3	0.0	2,0	5.6	4.8	0.8
Sal	0.5	6.3	3.6	1.7	1.0	29.2	41.6	3.2	N/A	N/A	N/A	N/A
Molly	N/A	22.7	14.3	12.5	1.0	7.4	18.0	2.5	N/A	2.0	0.5	0.5
Austin	0	1.7	0	0	5.0	20.5	9.6	0.8	N/A	N/A	N/A	N/A
Matilda	1	4.0	6.0	1.0	0	7.5	11.5	0	6.3	13.6	13.6	9.5

Note: This table depicts the average break point for each condition. The baseline condition does not include data from the initial baseline phase.

Figures

Figure 1

Results of the PSPA for all Participants

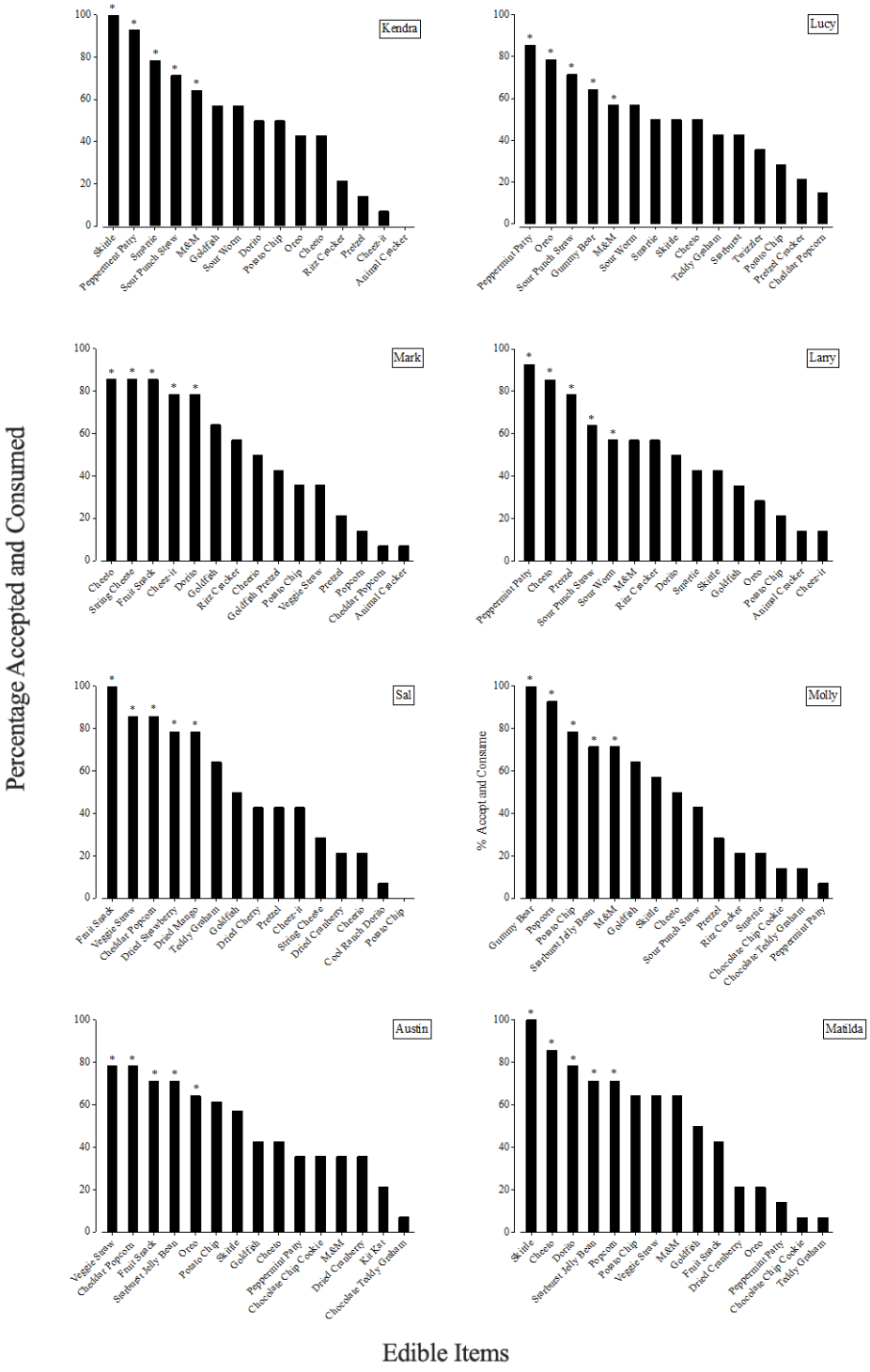


Figure 2

Results of the MSWO for Mark and Larry

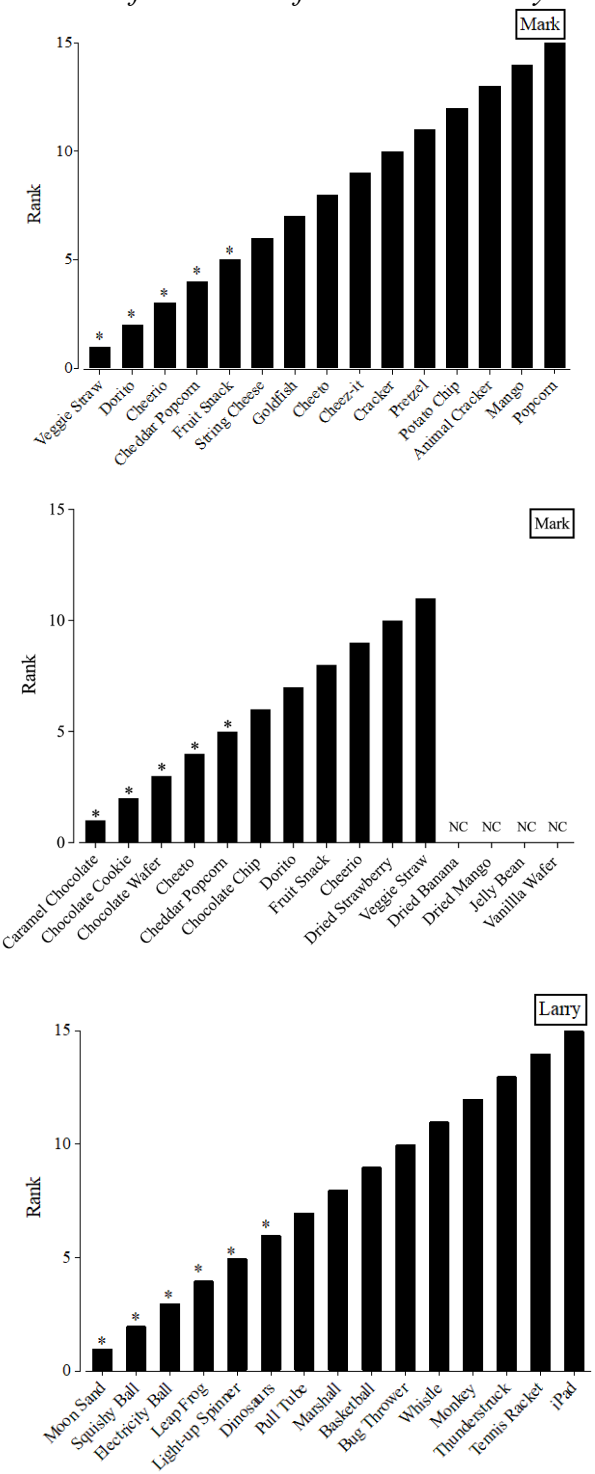


Figure 3

Results of the Token Training for All Participants

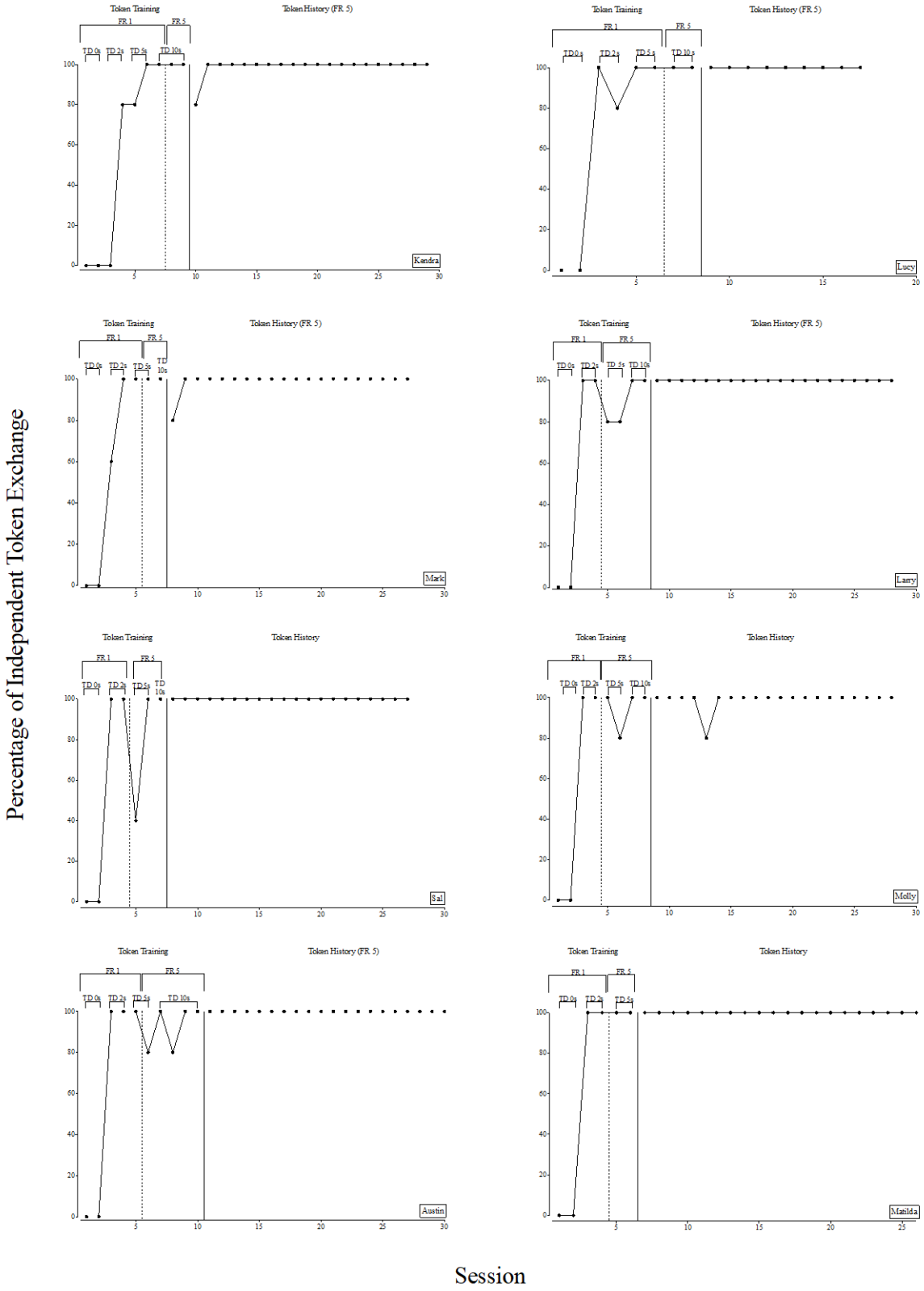


Figure 4

Results of the Free Operant Preference Assessment for all Participants

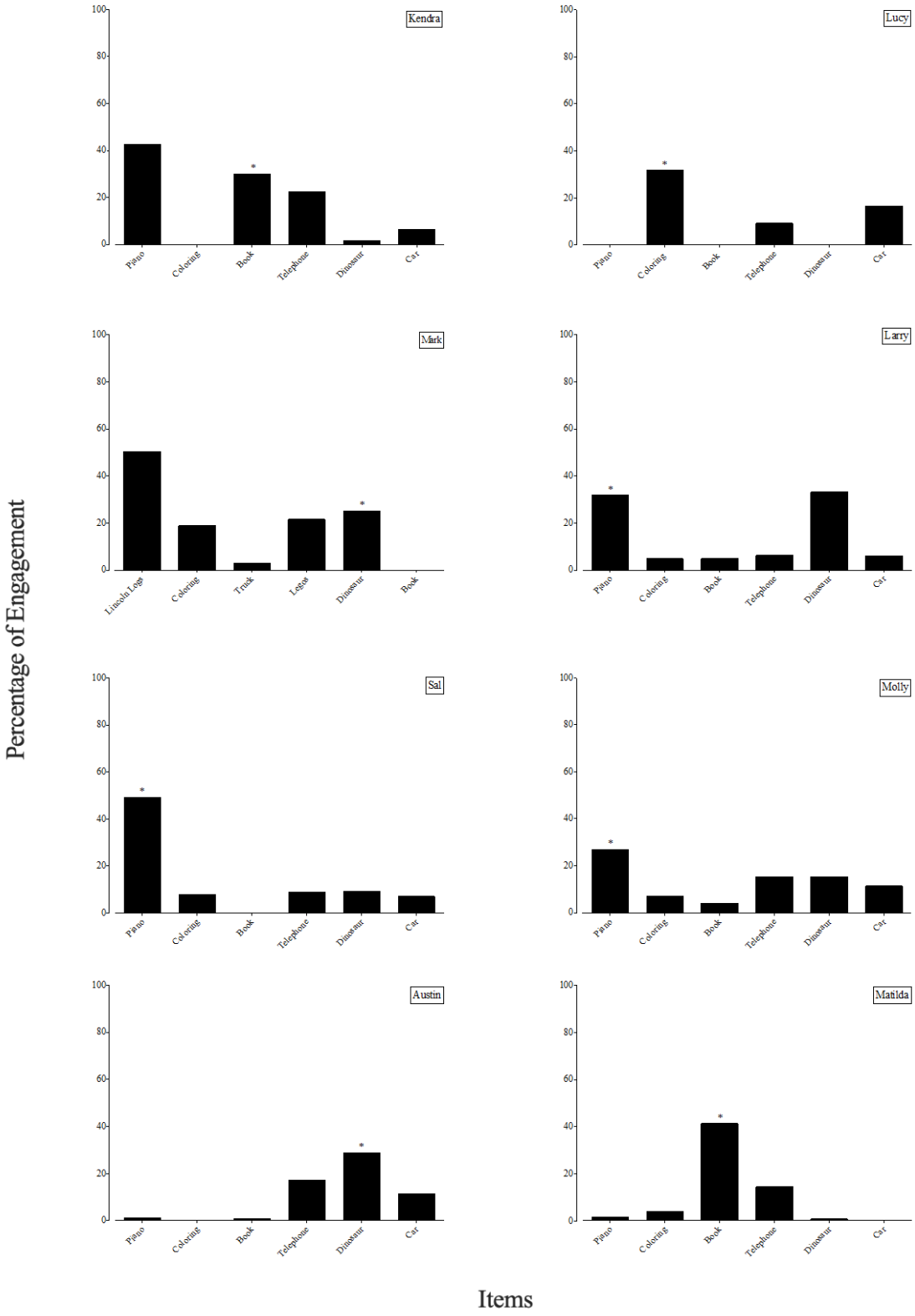


Figure 5

Results of the Reinforcer Comparison for Kendra

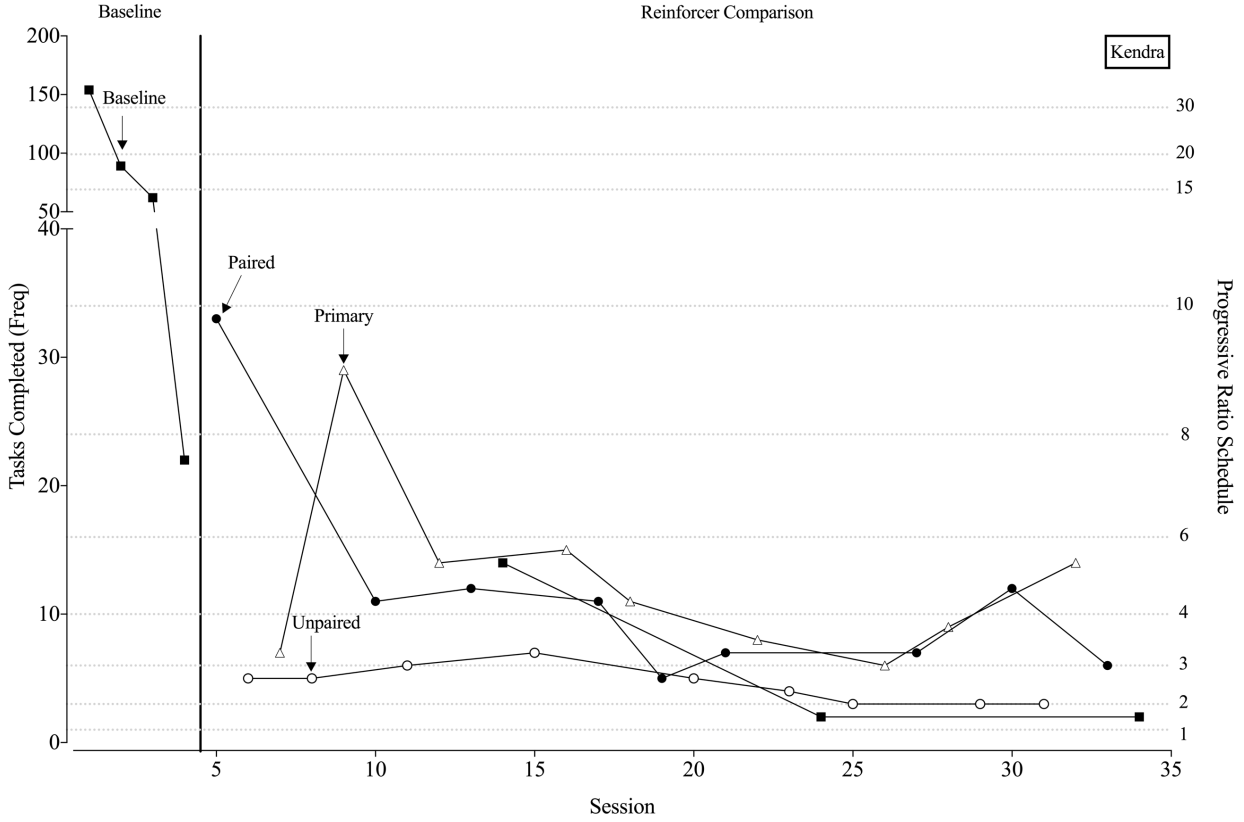


Figure 6

Cumulative Number of Responses during the Reinforcer Comparison for Kendra

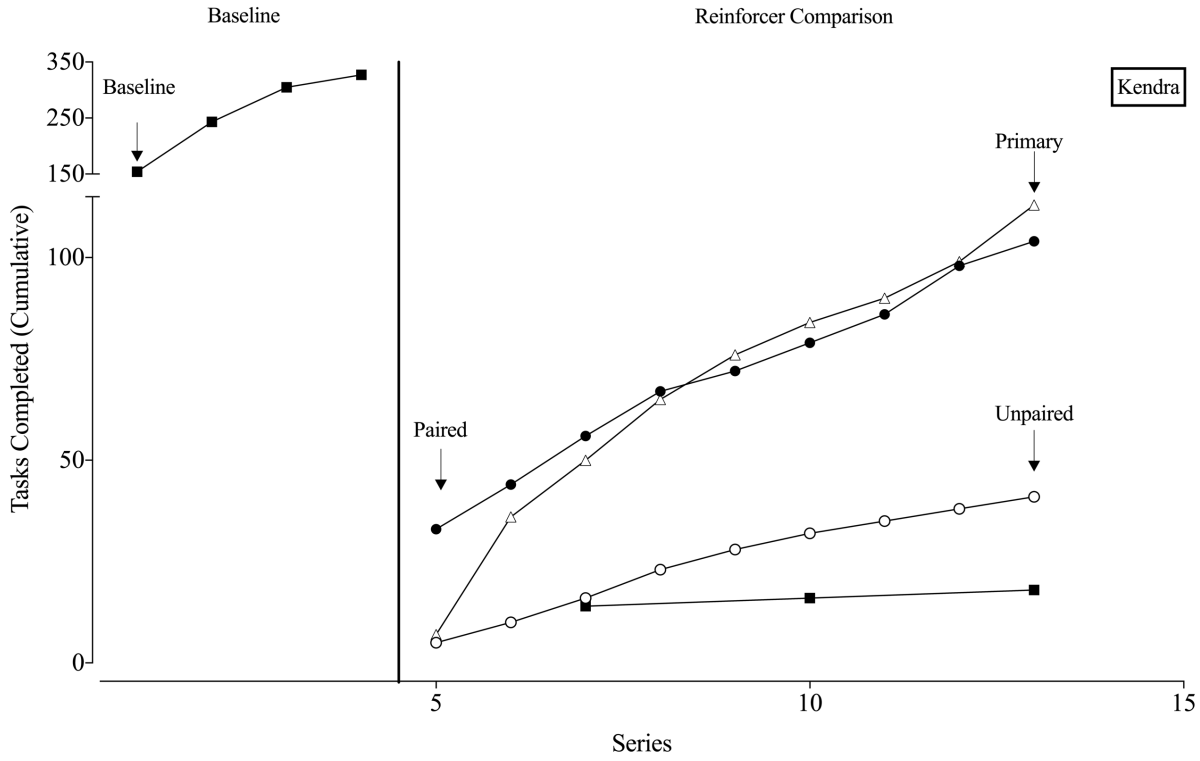


Figure 7

Results of the Reinforcer Comparison for Lucy

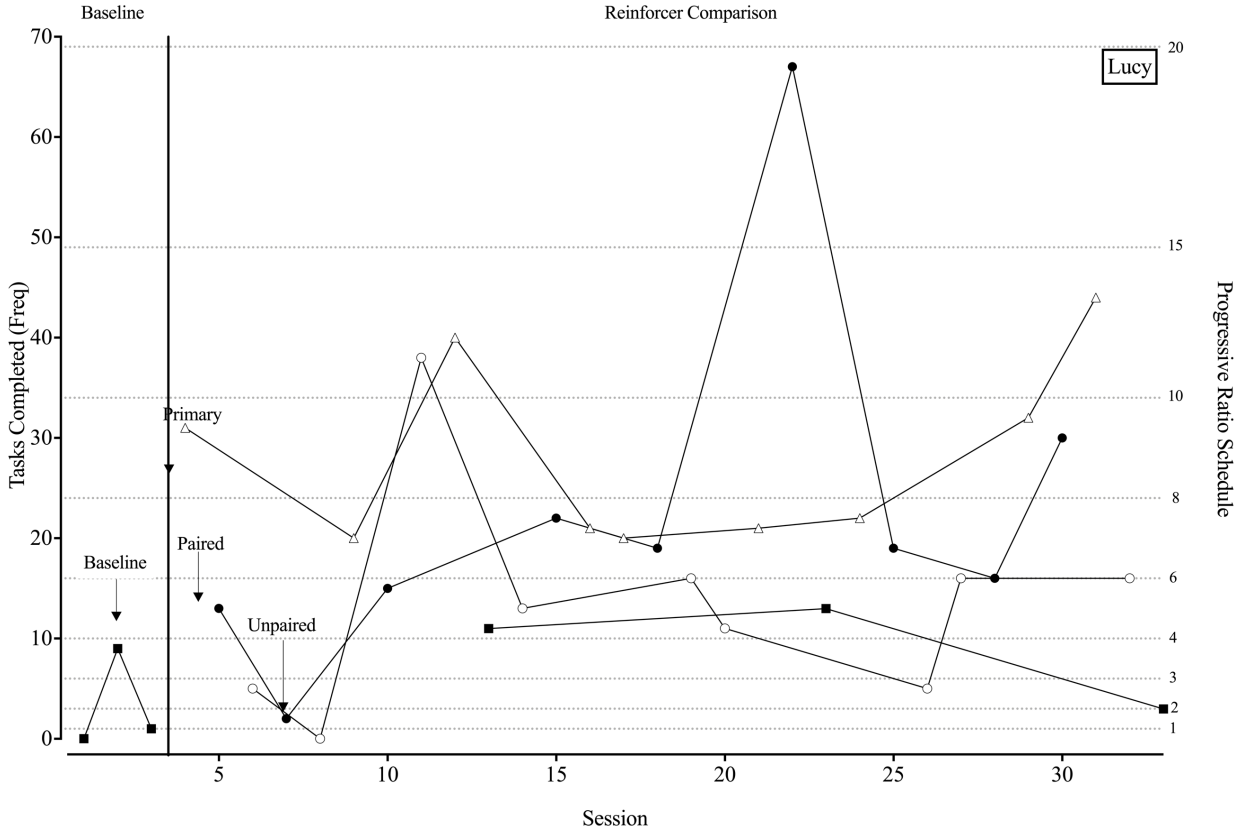


Figure 8

Cumulative Number of Responses during the Reinforcer Comparison for Lucy

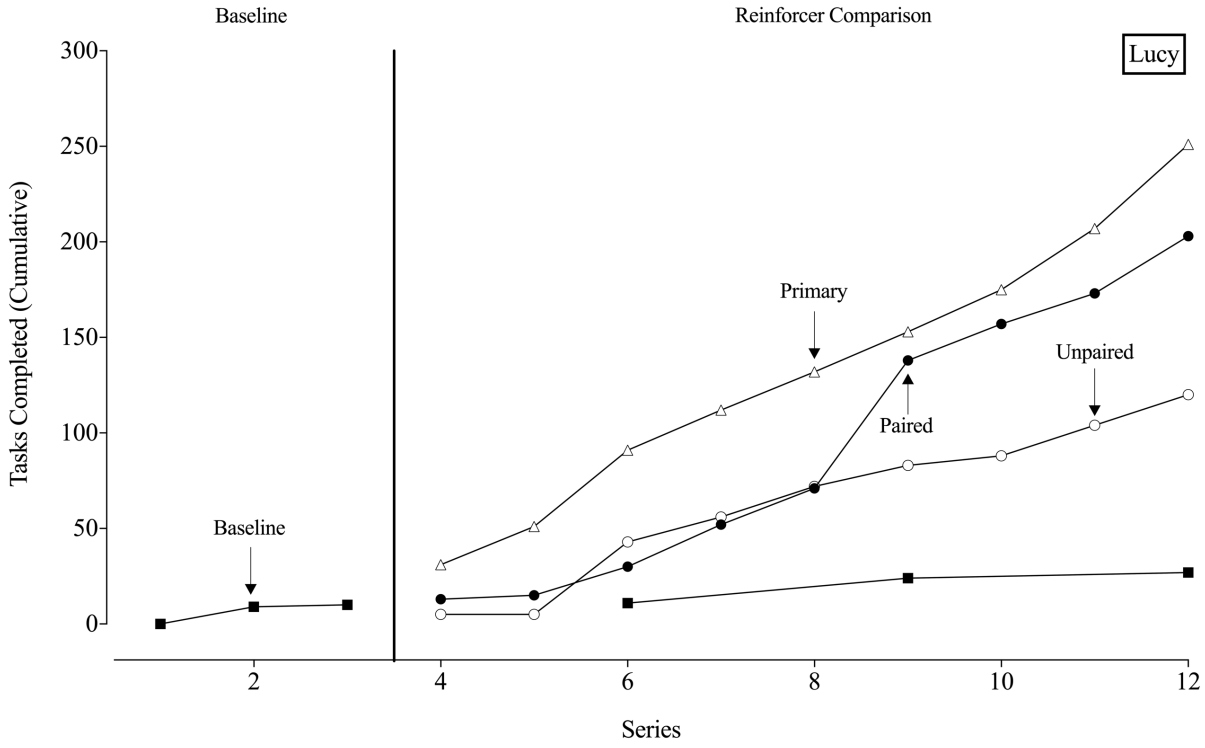


Figure 9

Results of the Reinforcer Comparison for Mark

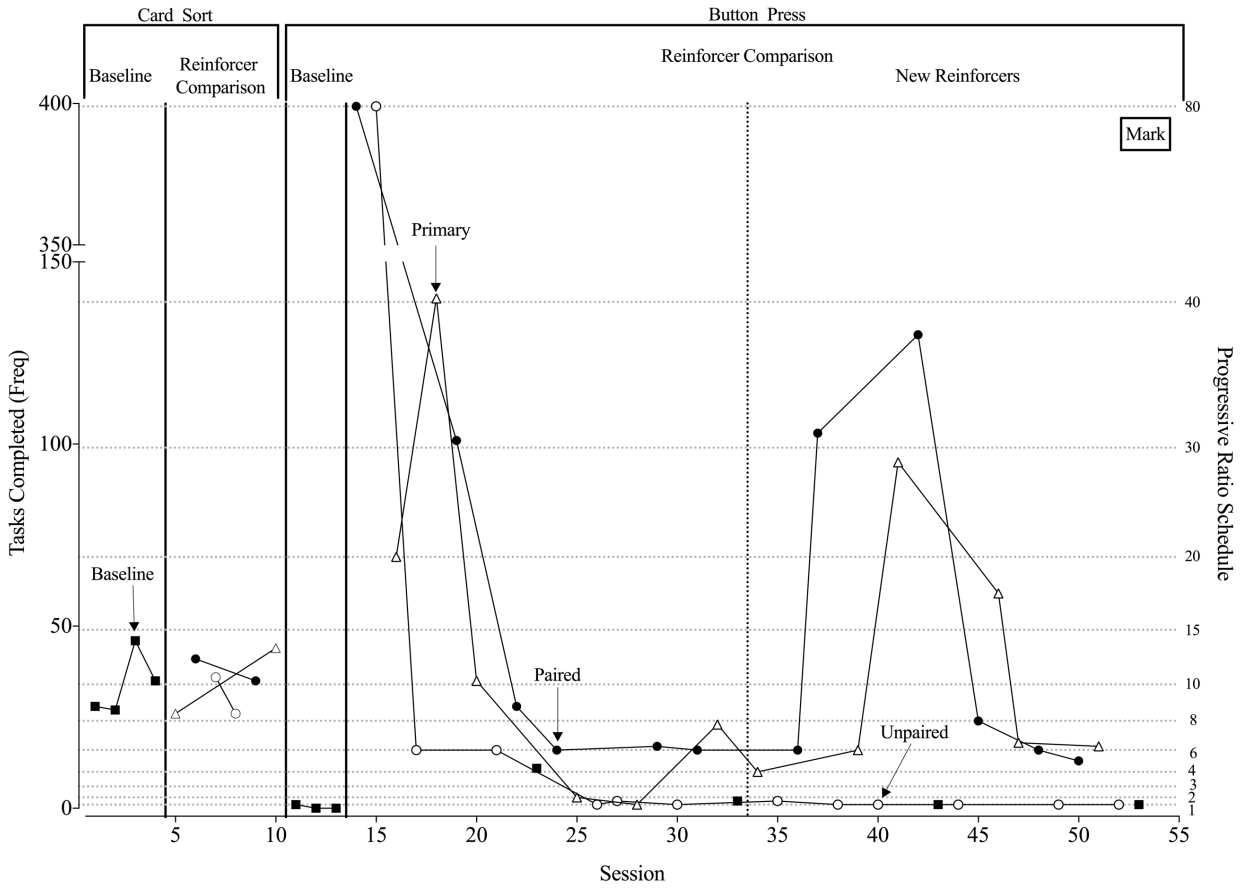


Figure 10

Cumulative Number of Responses during the Reinforcer Comparison for Lucy

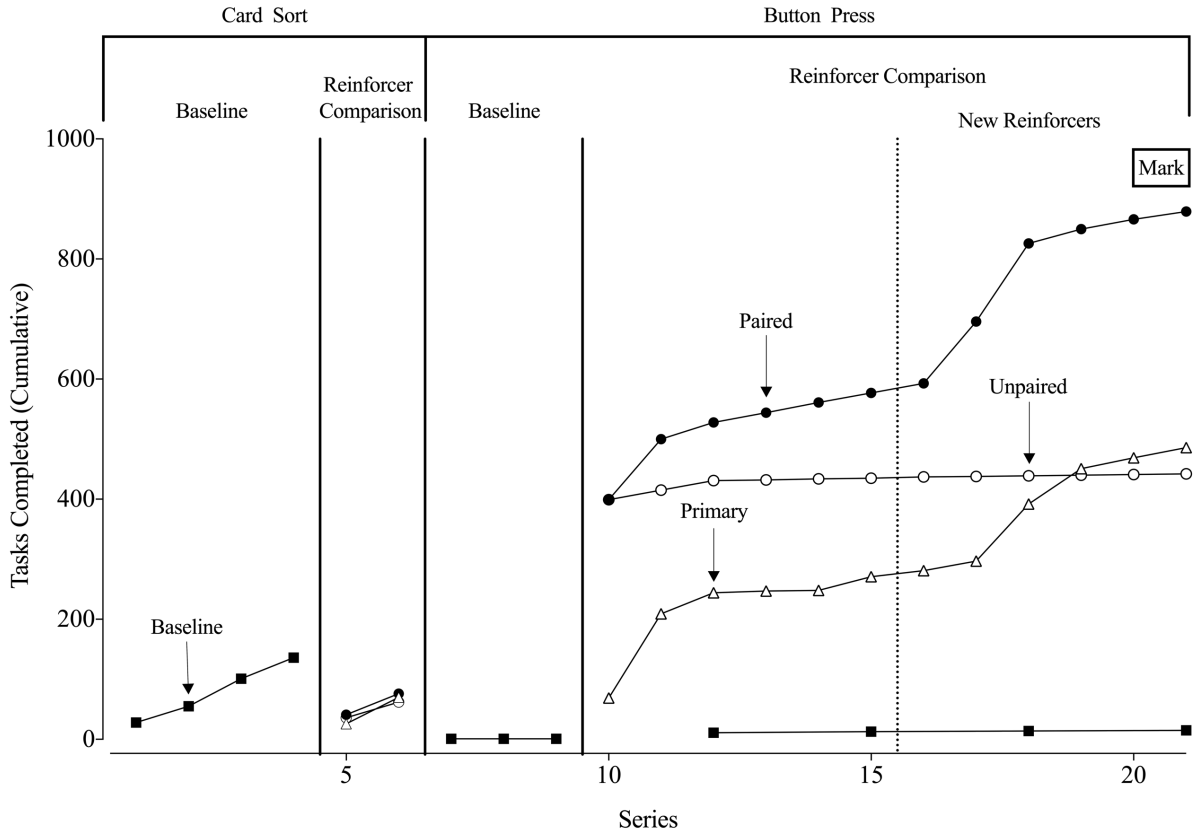


Figure 11

Results of the Reinforcer Comparison for Larry

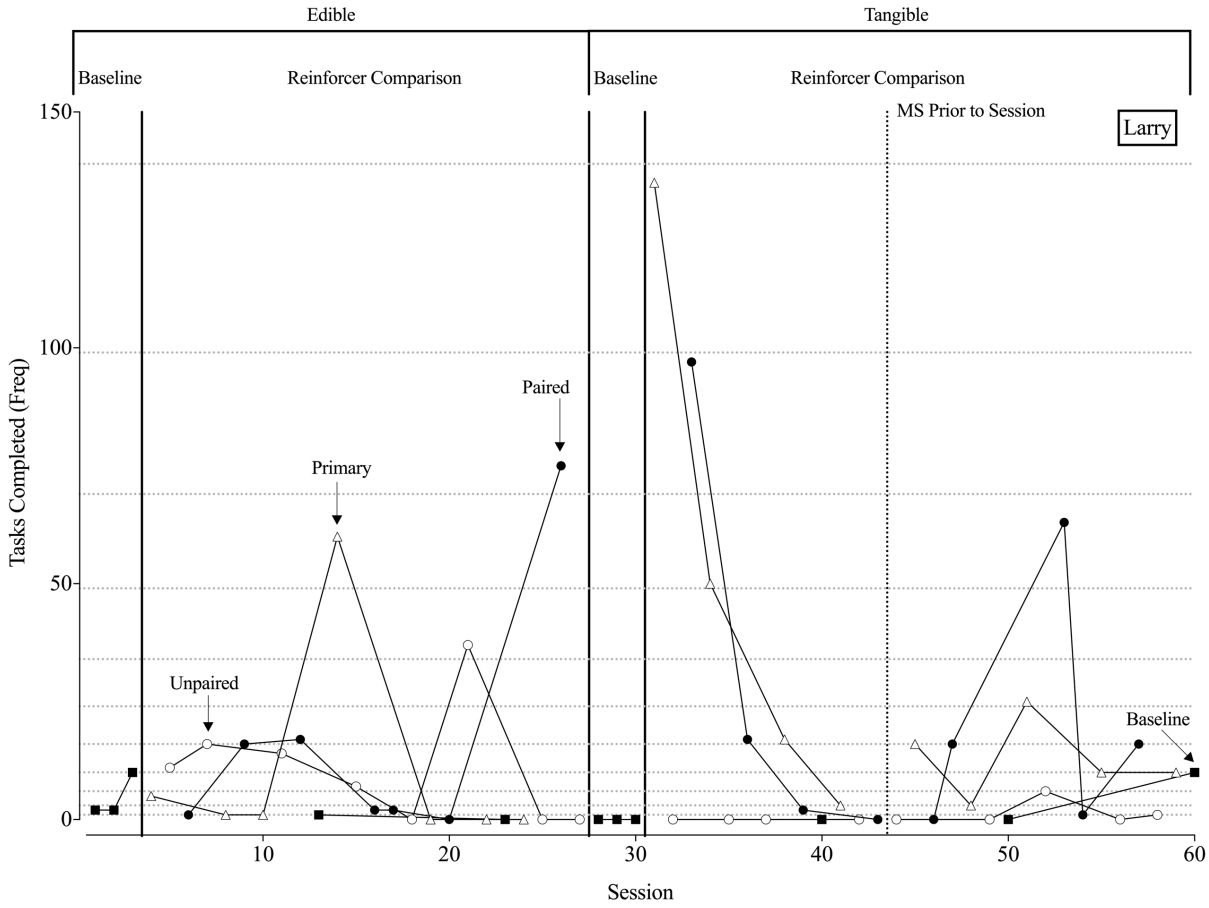


Figure 12

Cumulative Number of Responses during the Reinforcer Comparison for Larry

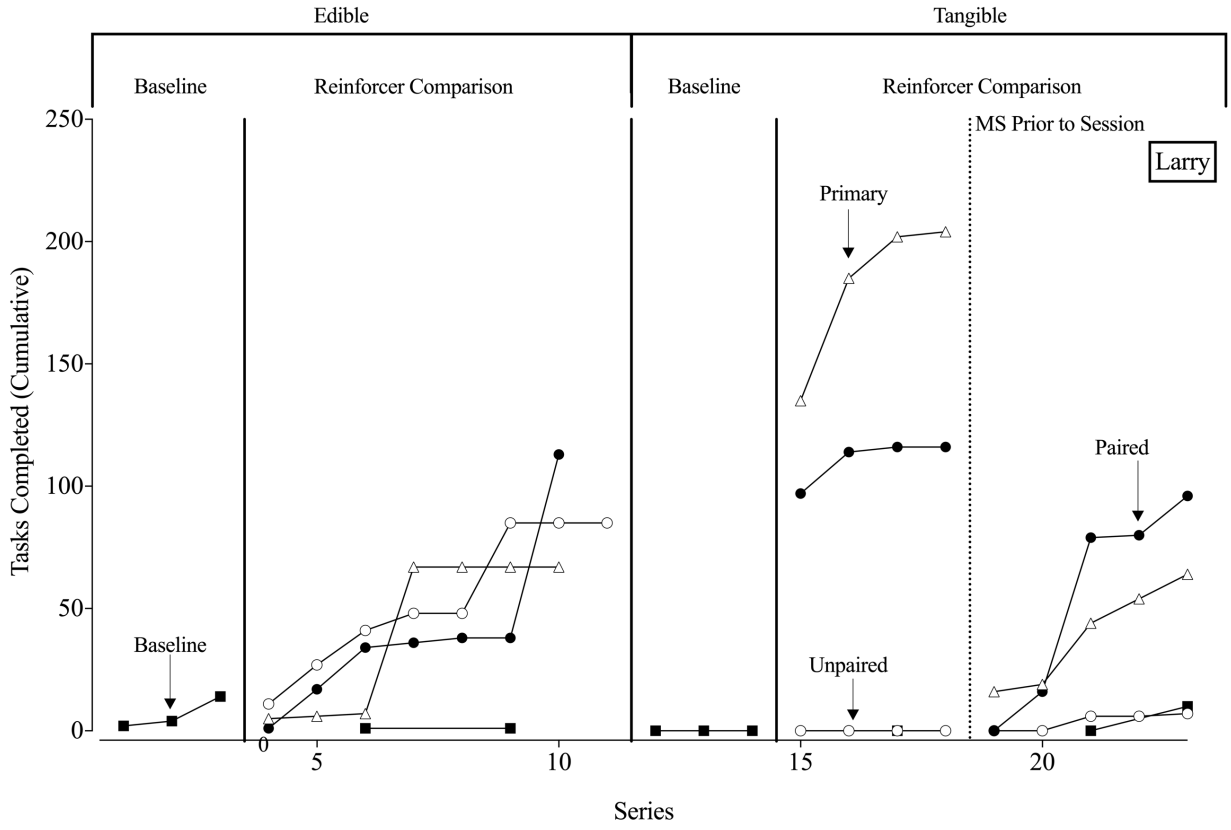


Figure 13

Results of the Reinforcer Comparison for Sal

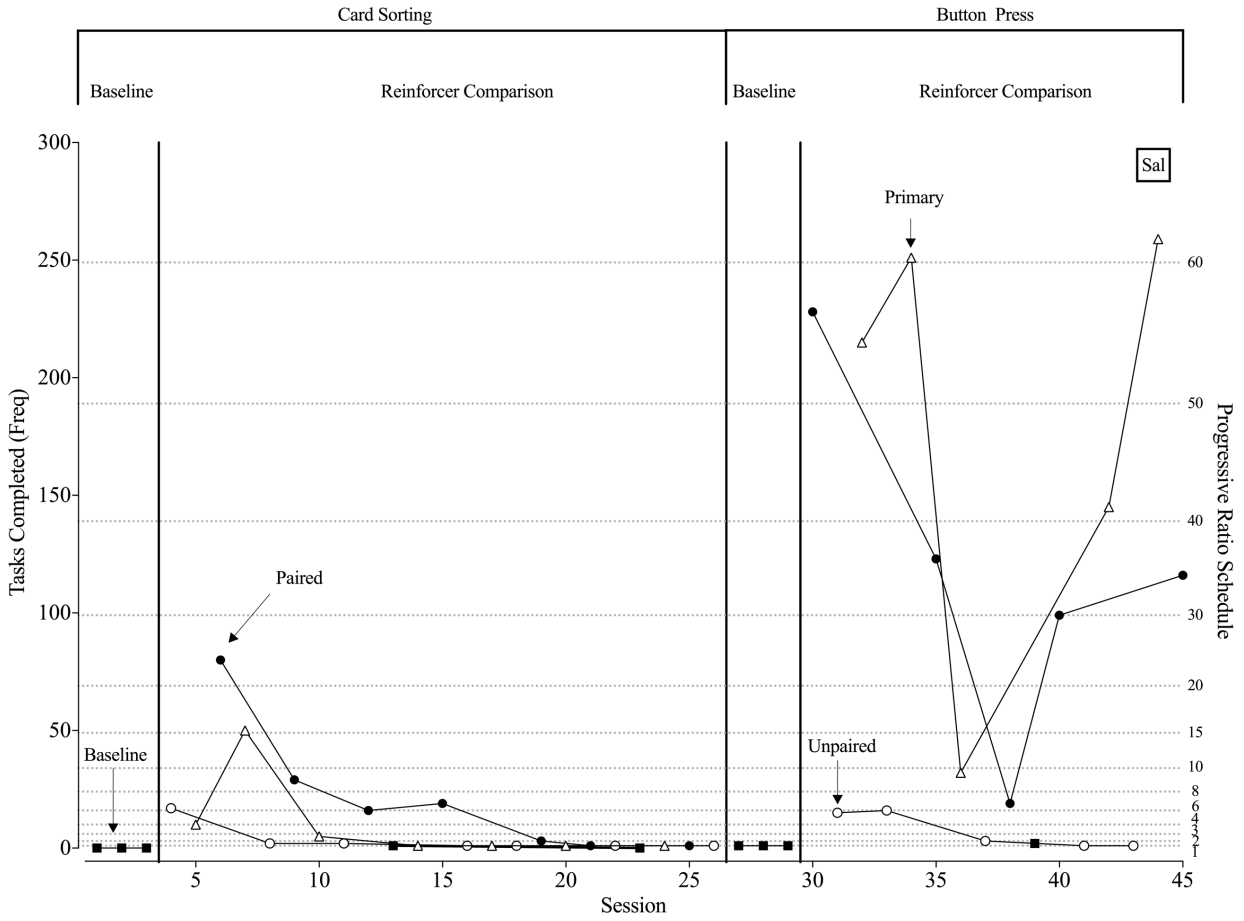


Figure 14

Cumulative Number of Responses during the Reinforcer Comparison for Sal

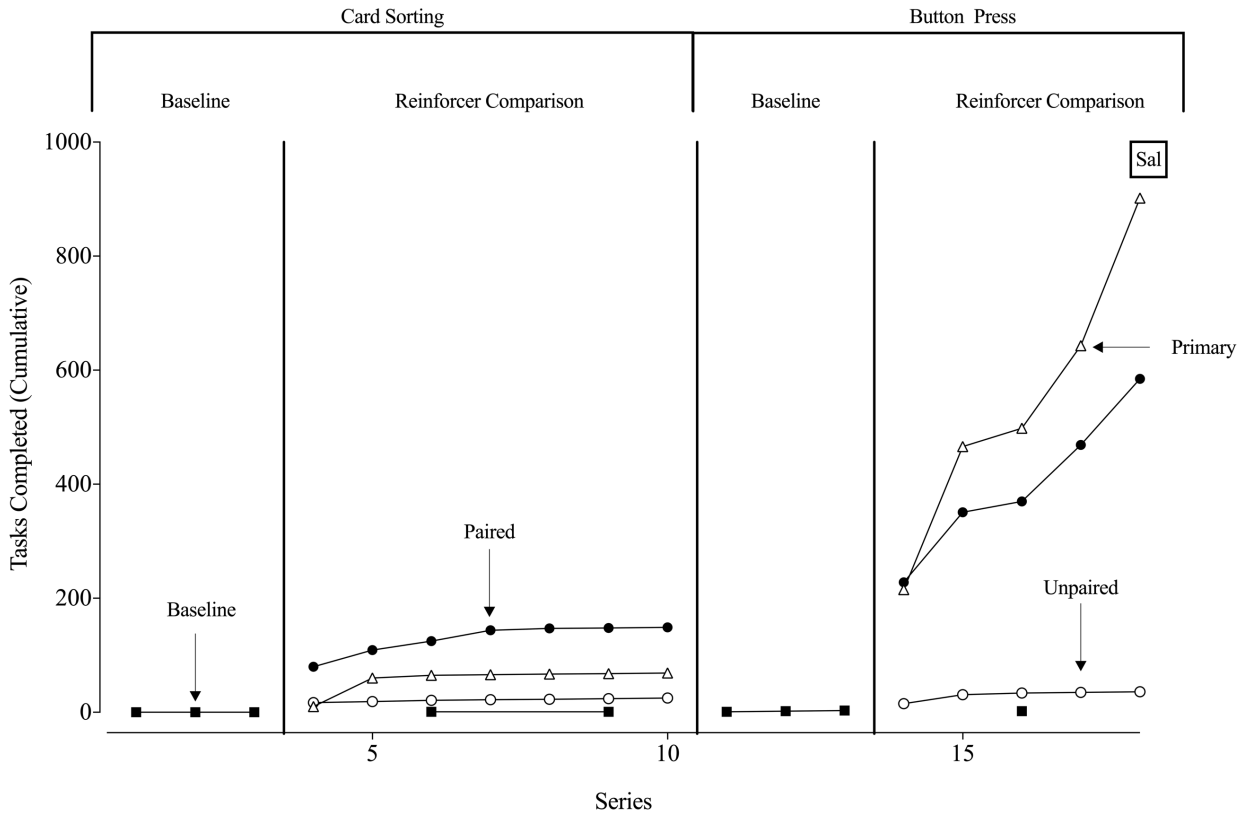


Figure 15

Results of the Reinforcer Comparison for Molly

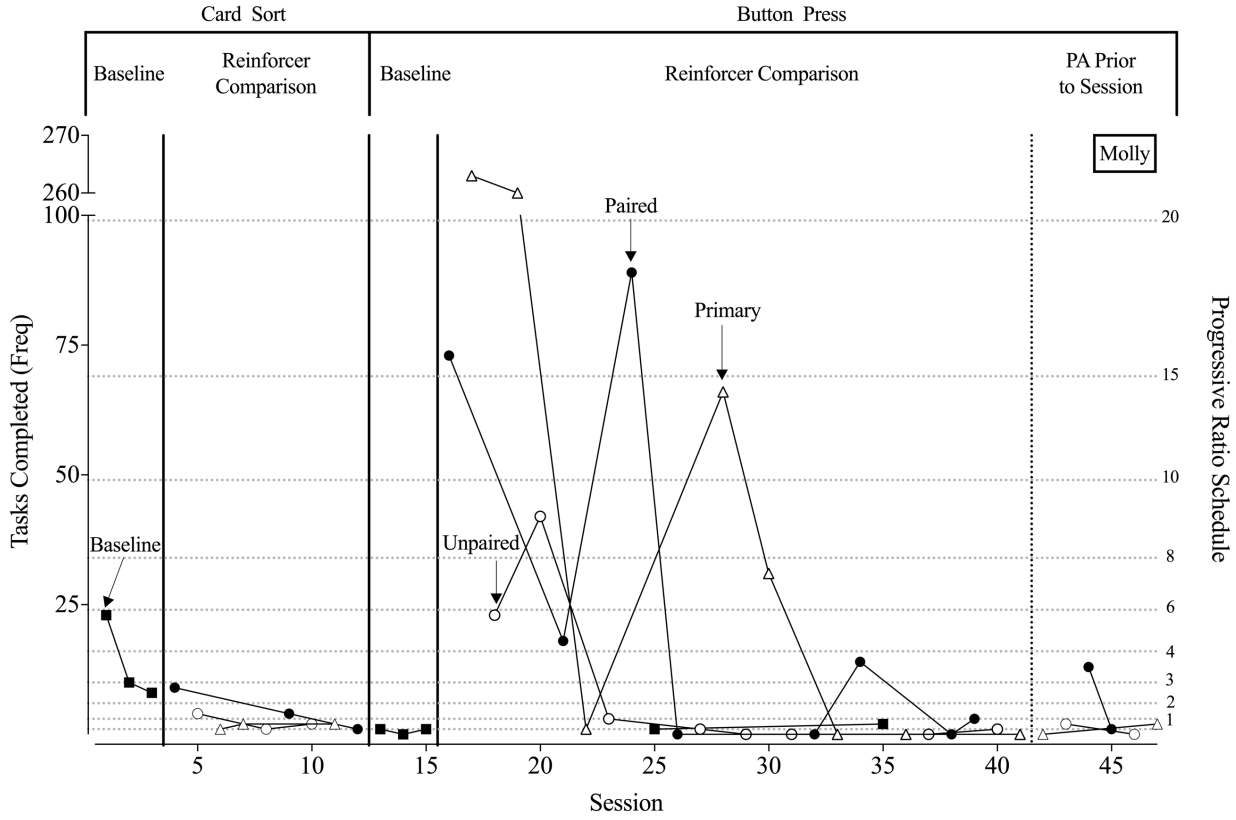


Figure 16

Cumulative Number of Responses during the Reinforcer Comparison for Molly

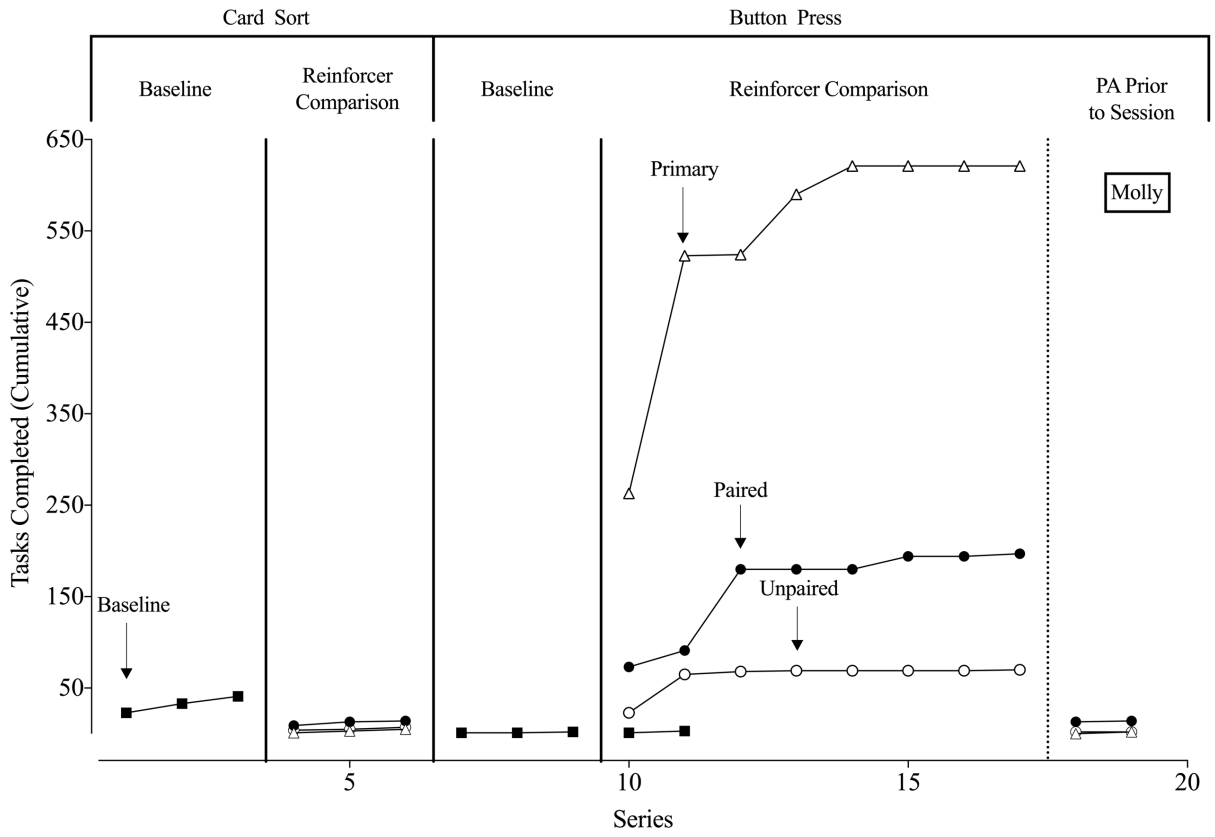


Figure 17

Results of the Reinforcer Comparison for Austin

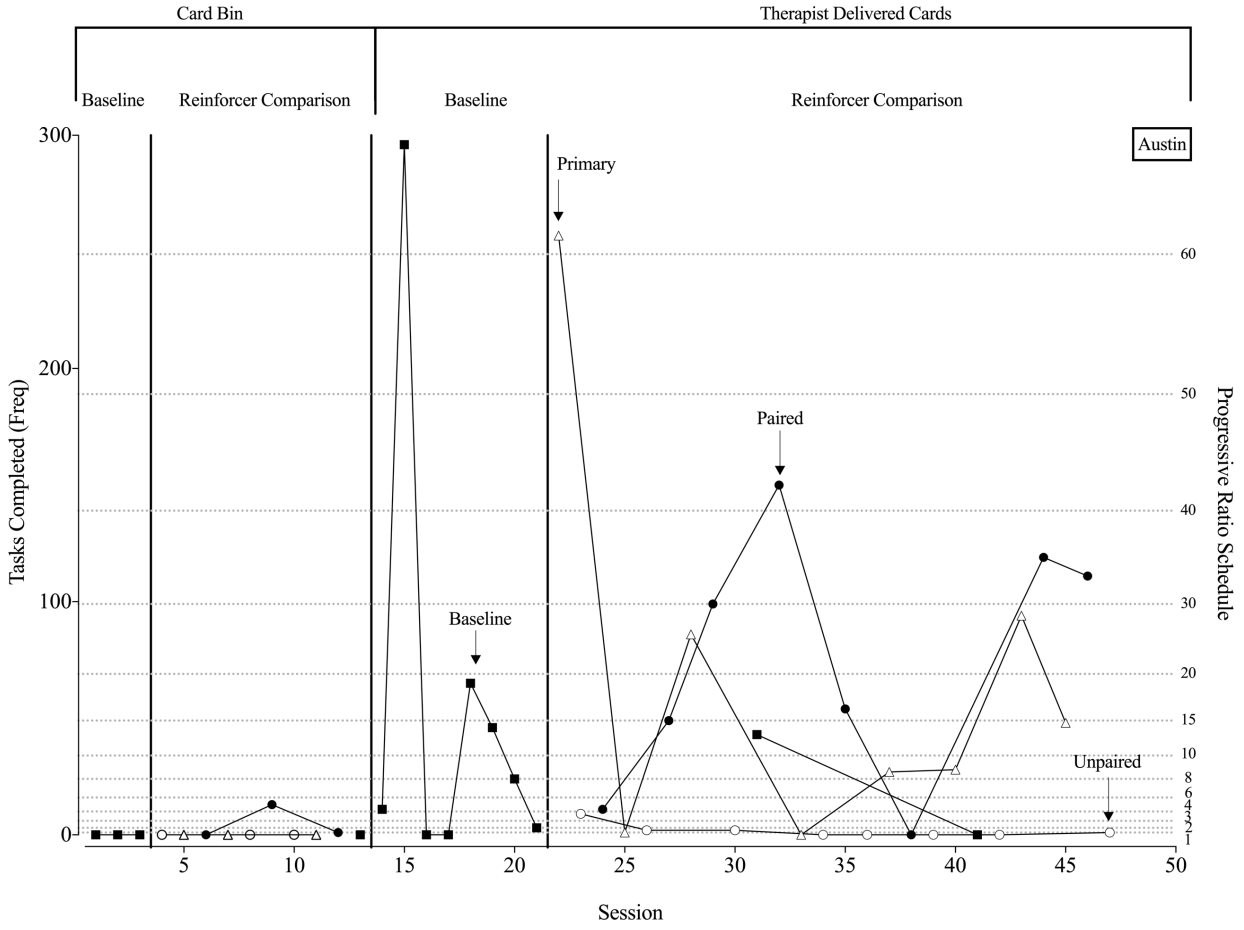


Figure 18

Cumulative Number of Responses during the Reinforcer Comparison for Austin

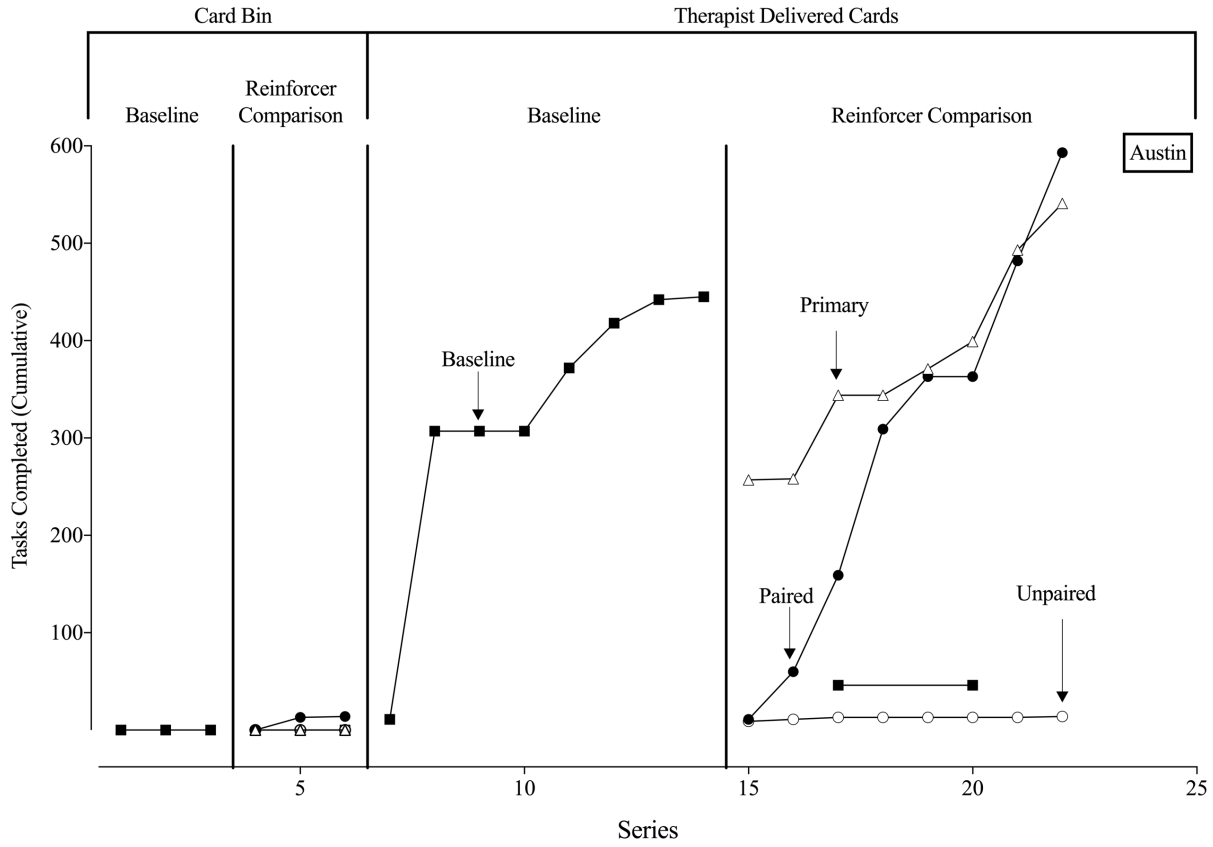


Figure 19

Results of the Reinforcer Comparison for Matilda

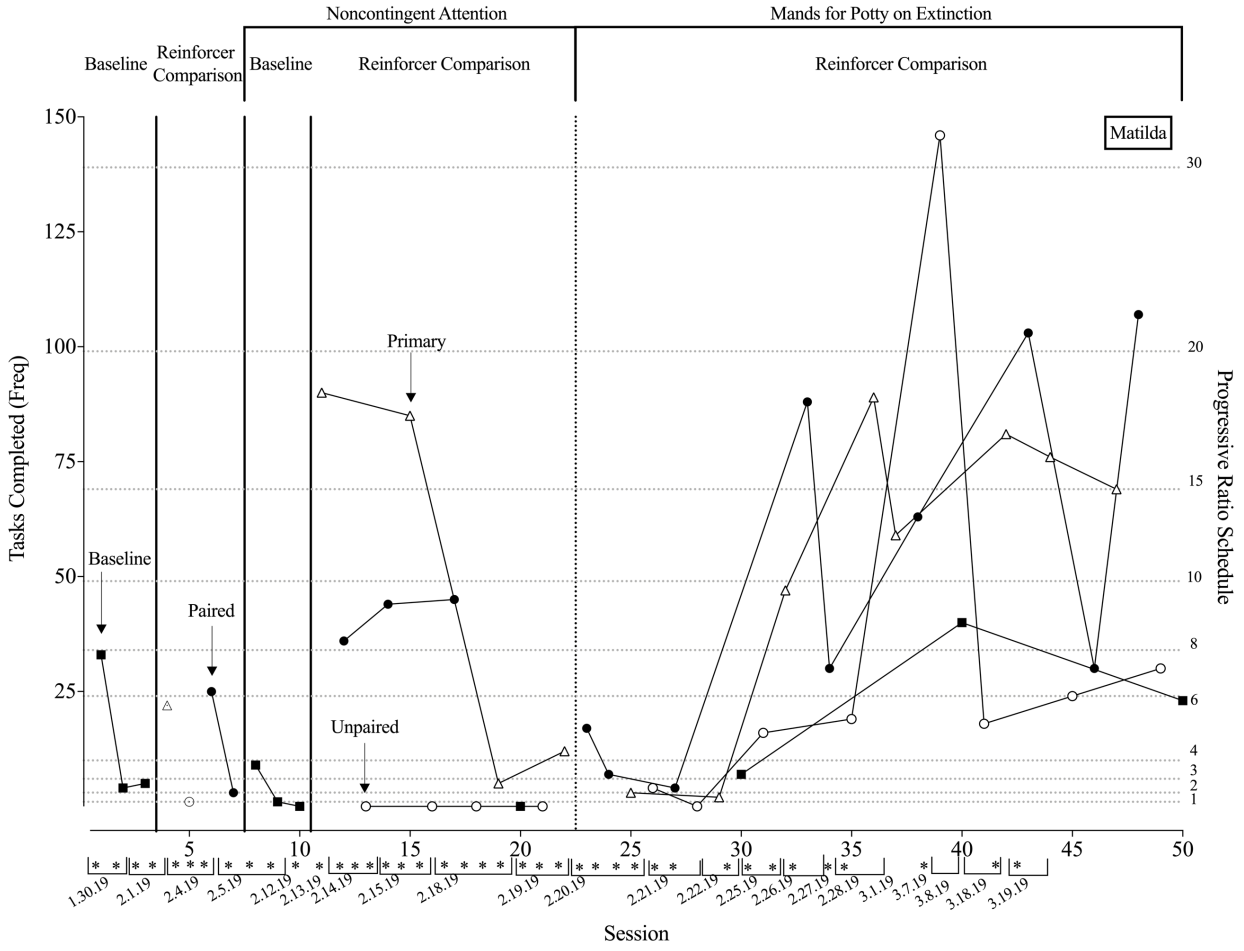
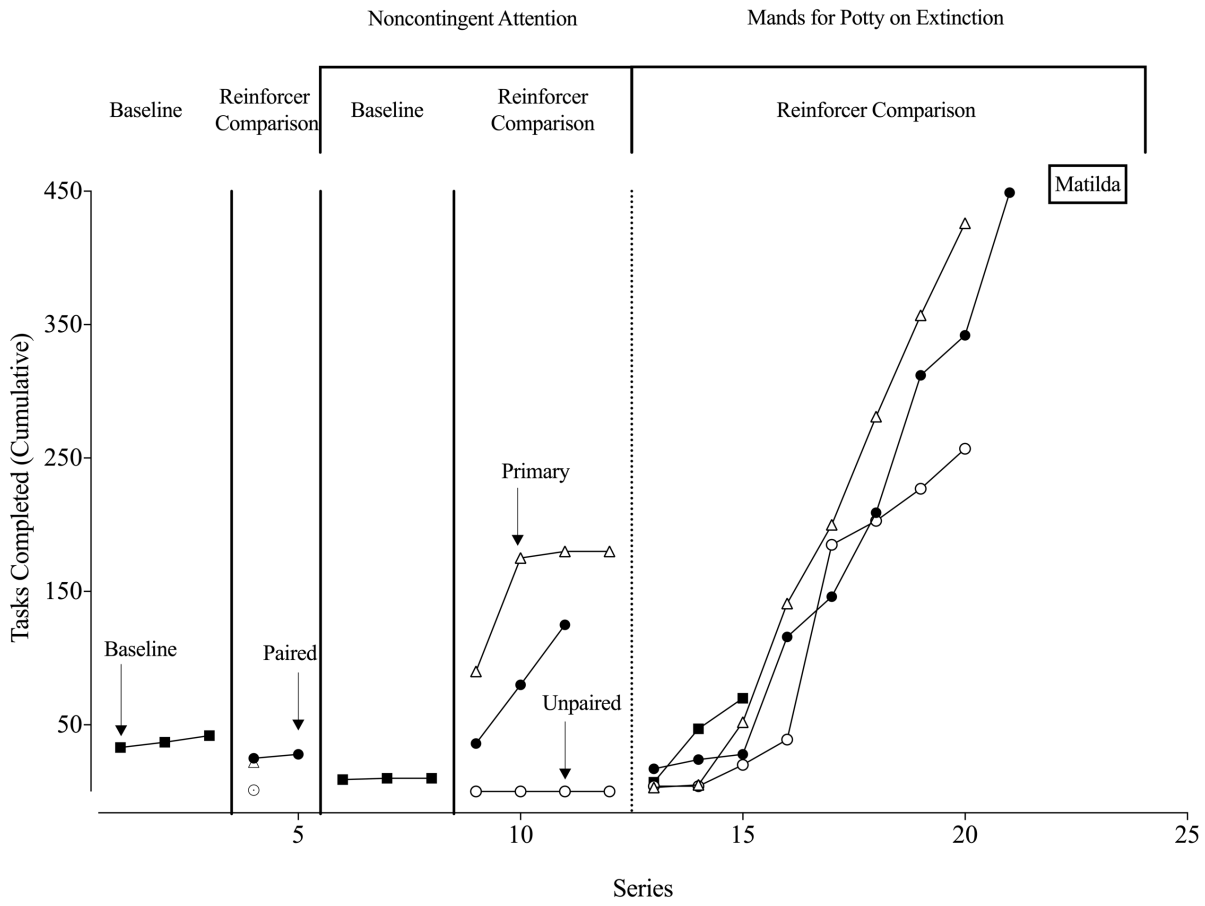


Figure 20

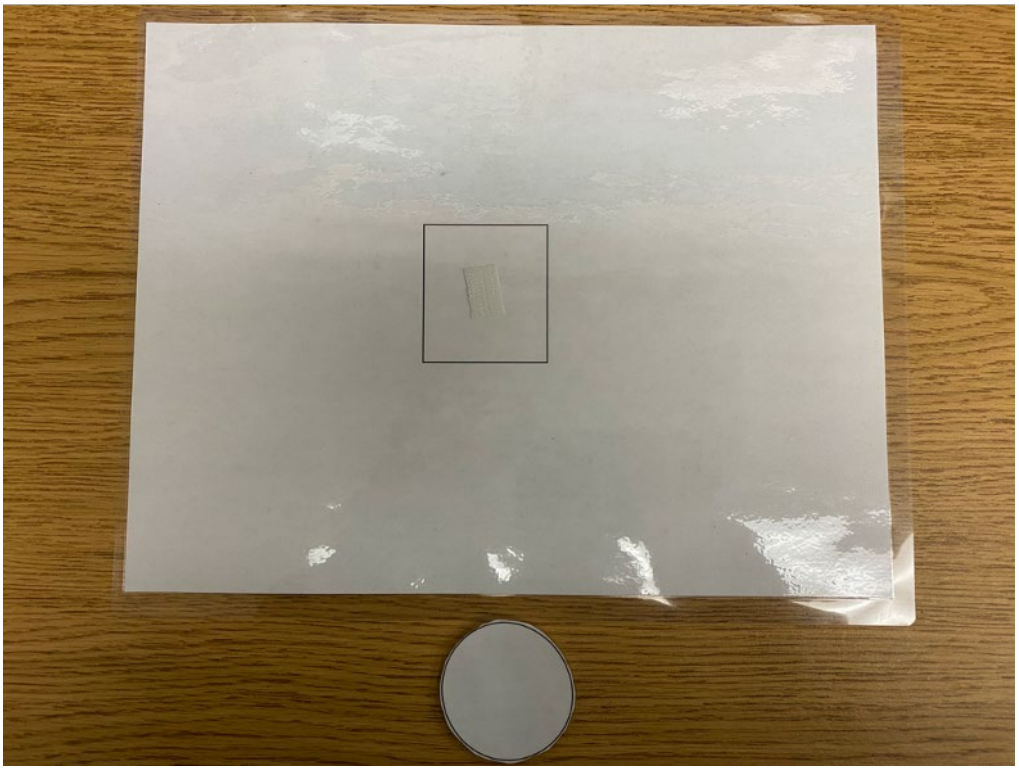
Cumulative Number of Responses during the Reinforcer Comparison for Matilda



Appendices

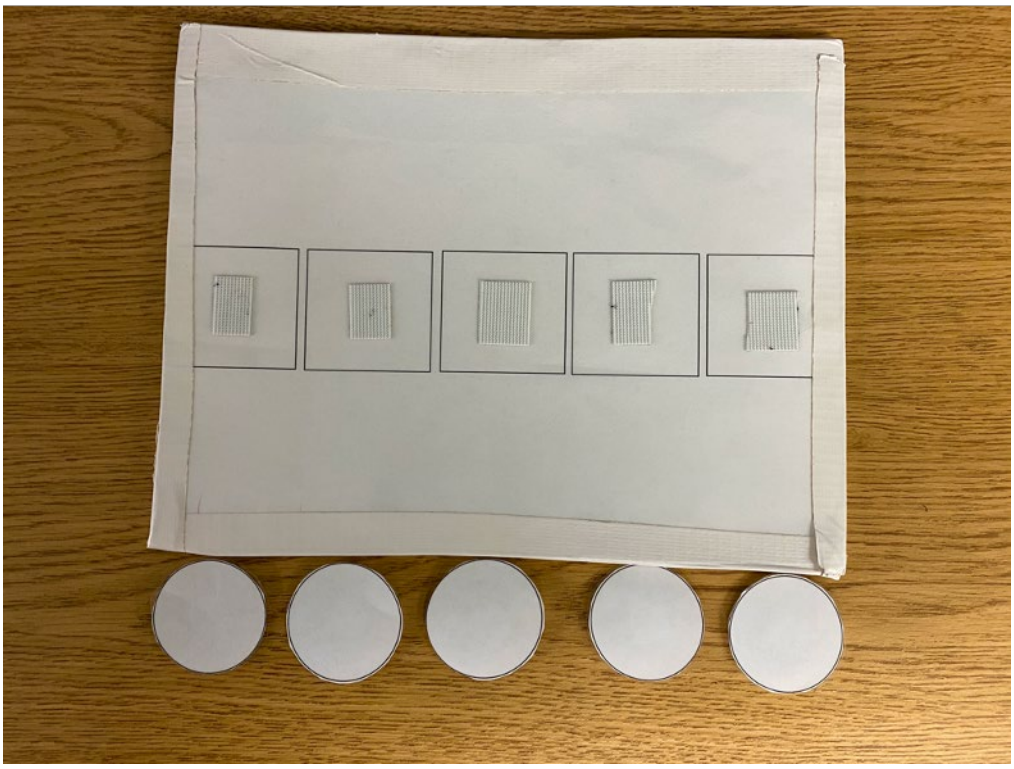
Appendix A

Initial Paired Token Board



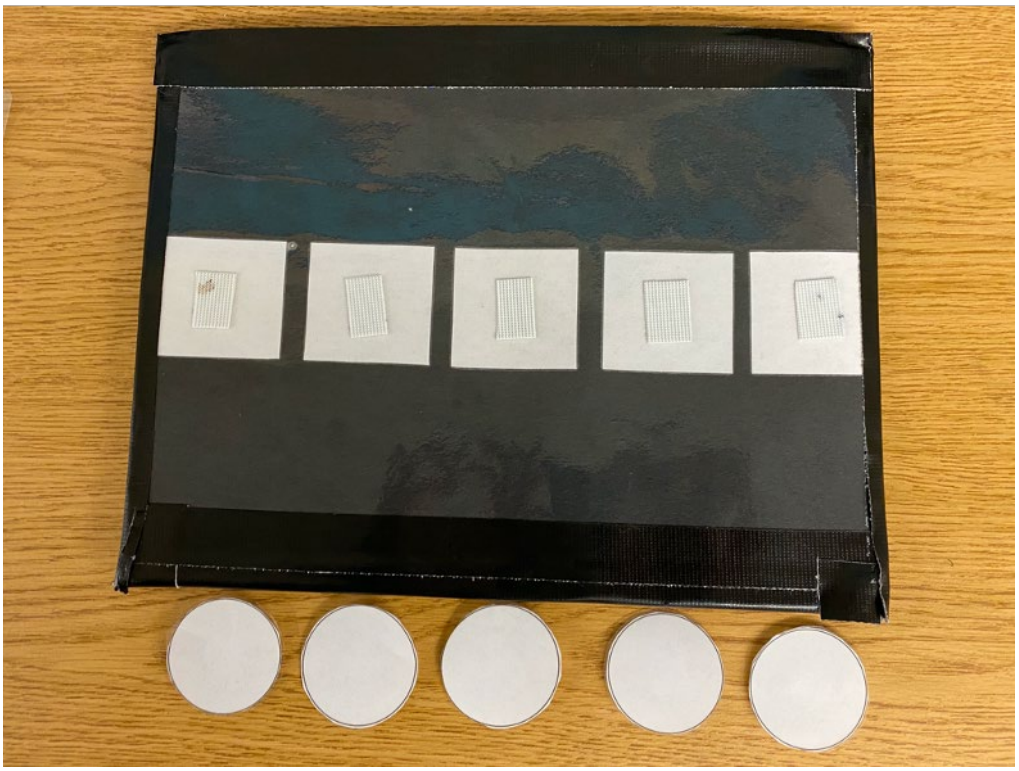
Appendix B

Final Paired Token Board



Appendix C

Unpaired Token Board



Appendix D

Follow-Up Study: Proposed Method

Follow-Up Study Method

Participants and Setting

Young children with and without disabilities will participate in the follow-up study. The setting will be identical to the initial study.

We will obtain approval form the Human Research Protection Program at the University of Kansas. We will obtain parents or guardians informed consent prior to the participant participating in this experiment. Additionally, the experimenters will obtain assent from the participants prior to conducting each session. Experimenters will ask the participants if they would like to go to research. If the participant refuse, no sessions will be conducted at that time.

Materials

Sessions will take place in a 3 m by 3 m session room equipped with a one-way window adjacent to one of the preschool classrooms. Data will be collected on computers and all sessions will be recorded on an iPod located behind the one-way window.

The room will be equipped with two chairs and a table and will only contain the relevant materials for a given session. Instructional materials and a control item will be present across all conditions. Instructional material will include a dowel rod glued to a wooden base and small circular stacking cards with a hole pierced through the middle (such that they can be stack on the dowel rod, a smart device (e.g., iPad), and a Boom Cards account and application including an additional device to review the child responses. Boom Learning is a learning tool on a smart device that an individual can use to create interactive lessons. Using the platform, we will create a set of Boom Cards which will include online matching stimuli. This apparatus and task

arrangement will make it such that no therapist interaction will be needed (the task can function as a free operant). The program will occupy the entire screen and participants can neither close the program or access other programs on the device. The targeted exemplar will be depicted in the middle of the screen larger than the rest of the stimuli. To the right of the current exemplar will be an array of three possible choices, one of which will be the correct response, an identical picture of the targeted exemplar (see appendix D1 for an example). Although the application allows for sound effects; these will be disabled for the purpose of the current study to minimize any experimentally unprogrammed consequences. The program will be arranged such that when the correct response is emitted, a green circle that bounces around the picture will appear and the application will automatically advance to the next exemplar. If the participant emits the incorrect response, a red X that bounces around the picture will appear across the selected picture. This X will remain until the correct answer is selected. The deck will consist of 110 matching cards, because that will be the maximum number of possible responses for a given session. The control item will be identified using a free operant preference assessment and consisted of one of the following: a small piano keyboard, coloring materials, a dinosaur, a car, or a book.

We will use a variety of edible items that will be identified via caregiver report to include in our preference assessments. The items that are identified as high-preference items will be present in the primary reinforcement and paired token conditions. Finally, three different token boards will be used throughout this study. The first token board will be used during the token training and will consist of a laminated 8.5 by 11 piece of paper with a triangular box in the center with a piece of Velcro adhered to the middle and one token which will be a small white triangular laminated piece of paper with Velcro on the back (see appendix D2). The second token board will be used during the token training and the token comparison and will consist of a

laminated 8.5 by 11 piece of paper with a five triangular boxes equally spaced with a piece of Velcro adhered to the middle and five token which will be small white triangular laminated pieces of paper with Velcro on the back (see appendix D3).The third token board will be a black circular piece of laminated paper with square Velcro makers and five small square laminated pieces of black paper with Velcro on the back (see appendix D4).

Measurement, Interobserver Agreement, and Treatment Integrity

Graduate and undergraduate students will collect data on BDataPro™ (Bullock et al., 2017)—a data collection software. As in the initial study, all data collectors will complete a training that includes observing six videos that increase in the complexity of data collection. The criterion to advance to the next video will be scoring each video with at least 90% integrity for each response. Additionally, if an observer's IOA falls below 80%, that observer will practice scoring sessions for the current study until all scores are above 90%. At that point, that observer may began collecting data again.

The data collection procedures and operational definitions for the PSPA and free operant preference assessment will be identical to the initial study. Additionally, the data collection procedures and operations definitions for the token training and the reinforcer assessment will be identical to the initial study with two exceptions. During the token training, the task response will be defined as placing a card with a hole in the center onto a dowel rod and releasing the card. Data will be recorded using a frequency measure. During the reinforcer assessment, the task response will be matching. Matching will be defined as selecting the corresponding picture out of an array based on the target picture. Data will be recorded using a frequency measure. Additionally, data will be recorded by the observers viewing a device that mirrors the participants device (using zoom).

Two observers independently will record responses during at least 33% of sessions across each assessment and condition within each assessment to evaluate IOA. The procedures for calculating IOA will be identical to the initial.

During at least 33% of sessions, observers will collect data on procedural integrity for token delivery and reinforcer delivery during the token training and the reinforcer comparison. The procedures for assessing procedural integrity will be identical to initial study.

Experimental Design and Procedures

Experimental Design

A multiple probe within a multi-element design will be used to evaluate experimental effects of the intervention. Experimental control will be evidenced by differentiated rates of responding during the test (i.e., paired token, primary reinforcement, unpaired token) and baseline conditions.

Procedures

Paired Stimulus Preference Assessment. A 15-item PSPA, as described by Fisher et al. (1992), will be conducted to identify five high-preference edible items to be used as potential reinforcers throughout the study. The procedures will be identical to the initial study.

Multiple-Stimulus Preference Assessment. A one trial multiple-stimulus preference assessment (MS; DeLeon & Iwata, 1996) will conducted during each reinforcer delivery (i.e., each time a reinforcer is earned, the participant will select which item they want to consume from an array of 5). The item that is selected will be delivered immediately to the participant. The procedures will be identical to the initial study.

Token Training. Token training (DeLeon et al., 2014) will be conducted prior to the reinforcer comparison. The purpose of the token training is two-fold (a) to condition tokens as

reinforcers and (b) to train the participants to independently exchange their tokens to gain access to reinforcement. The procedures will be identical to the initial study with the exception that the target task will be a card stacking task instead of a card sorting task and the amount of reinforcement earned. We are choosing a different task, because we want to condition tokens as reinforcers and to train the participants to independently exchange their tokens without creating a history with the task that will be used during the reinforcer comparison. If the participants have a history with the token and the task that will be used during the reinforcer comparison, the results could be affected by that history. Additionally, a piece of edible reinforcement will be delivered for each token earned. For example, once the token training increases to an FR-5 exchange-production schedule, the therapist will deliver five pieces of the selected item to equate to the number of tokens earned (instead of one piece of edible item as in the initial study). We will make this modification, because we want the participant to have the history with the number of tokens equating to the magnitude of reinforcement. Additionally, this will reduce the likelihood of a potential confounding variable affect the results during the reinforcer comparison. The token board that will be used at the initiation of the token training will be a white rectangular token board with one Velcro spot and one triangular white token (see Appendix D2). The final token board will be a white rectangular token board with five Velcro spots with five triangular white tokens (see Appendix D3).

Similar to the initial study, a history will be created after the completion of the token training. The general procedures will be similar to those in the initial study; however, there will be three modifications including the task response, a change in session termination criteria, and the addition of a primary reinforcement condition. The therapist will state an instruction at the beginning of session that specifies the contingencies (e.g., “when you do X, you will earn a

token. After your token board is filled, you can trade in your token for treats"). The therapist will place the task (i.e., the iPad with the matching application open) in front of the participant and will instruct the participant to complete the task at the start of session (e.g., "here is your work, match the pictures"). The therapist will deliver the corresponding stimuli (i.e., primary reinforcement, token) on an FR-1 schedule for correct matching. The task in the token history condition will be a matching task that is displayed on an iPad using Boom Cards. This task will be chosen because it is discrete, can occur quickly, is likely already in the participant's repertoire, does not produce a permanent product, and it has clinical relevance (i.e., the child is able to practice matching pictures which is an important prerequisite skill for many skills they will need in kindergarten). We will create a history with the task that will be using during the reinforcer comparison to create a programmed history as this history will no longer created during the token training. The program will be arranged such that when the correct response is emitted, a green circle will appear and bounce around the selected picture and the application will automatically advance to the next exemplar. If the participant emits the incorrect response, then a red X will appear that will bounce around the selected picture. The therapist will observe the participant's responding but will not intervene contingent up incorrect responses. However, if the participant does not respond to the current target for 10 s, then the therapist will deliver a vocal response to keep working. The therapist will deliver the condition specific item (e.g., token or reinforcer) when the participant emits the correct response (even if it is preceded by an incorrect response).

A history will be created with both the paired token board and primary reinforcement. We suspect that the participant's history with paired tokens and the targeted task may have affected the results of the initial study (more exposure to earning reinforcement for completing a

specific task in the presence of the tokens could affect the results). Accordingly, we will create a history with the task that will be using during the reinforcer comparison with the primary and paired token condition to create an equal history with the two conditions that involve programmed reinforcement. Two sessions will be conducted per day, a primary reinforcement session and a paired token session to create this history. The order of the conditions will be randomized. Additionally, we will alter the length of session from the initial study to the follow-up study to be completion of five matching task. The therapist will deliver a choice of an edible item each time the participant correctly matches a picture during the history with primary reinforcement condition. This process will continue until the participant completes five matching tasks. The therapist will deliver a token each time the participant correctly matches a picture during the history with paired token conditions. The participant will exchange their tokens for five pieces of a chosen back-up reinforcer when the token board is filled (i.e., completion of five matching tasks). We are changing the session termination criteria to decrease the number of edible items the participant will consuming during the preassessments to decrease the likelihood of satiation. Additionally, we will alter the number of sessions during the token history condition to five sessions per condition (for a total of 10 sessions) to further decrease the likelihood of satiation.

Free Operant Preference Assessment. A free operant preference assessment (Roane et al., 1998) will be conducted prior to the start of the reinforcer comparison to identify moderately preferred toys to use as a control task throughout all reinforcer assessment sessions. The procedures will be identical to the initial study.

Reinforcer Comparison. The purpose of the reinforcer comparison is to extend the initial study to further evaluate the efficacy of primary reinforcement, paired tokens, and

unpaired tokens. The reinforcer comparison will be conducted similarly to those described in the initial study with a few notable differences including the PR schedule, the target response, the termination criteria, the instructions delivered in session, and the form of the token board. Due to the low rates of responding in the initial study possibly due to ratio strain, the PR schedule will be modified. To prevent rapid ratio strain (Jarmolowicz & Lattal, 2010), a PR schedule will be used in which the ratio requirement increases by one after two exposures to each step (i.e., PR 1, 1, 2, 2, 3, 3, 4, 4, 5, 5, 6, 6, 7, 7, 8, 8, 9, 9, 10, 10 [Roane et al., 2015]). The same task was used during token training and token history as was used in the reinforcer comparison in the initial study. It is possible that the history of the task response with paired tokens may have altered the results of the study. Therefore, a different task will be used in the reinforcer comparison in the follow-up study then the task that will be used in the token training. The Boom Cards matching task will be used during the reinforcer assessment, because it is more effortful than a button press, but it is discrete, can occur quickly, is in the participant's repertoire, and is a functional skill for the participants. Additionally, the termination criteria will be altered to no longer include that the participants can request to terminate the session. It was hypothesized that the participants in the initial study terminated session to gain access to preferred items outside of session; therefore, it was difficult to isolate the reinforcing value of the item in session. Additionally, because we will alter the termination criteria, we will alter the instructions at the beginning of session to remove the clear prompt that participants could terminate session. Finally, the token boards will be altered to aid in discrimination from the paired and unpaired token conditions.

We will use the same matching Boom Card application during the reinforcer comparison. As with the token history condition, the program will be arranged such that when the correct response is emitted, a green circle will appear that will bounce around the picture and the

application will automatically advance to the next exemplar. If the participant emits the incorrect response, then a red X will appear that will bounce around the picture across the selected picture. The therapist will observe the participant's responding but will not intervene contingent up incorrect responses or the absence of responding.

As in the initial study, the therapist will deliver the programmed condition-specific stimuli (i.e., primary reinforcement, paired tokens, unpaired tokens) after the completion of the PR requirement. The therapist will deliver the primary reinforcer (i.e., edible item) and token by placing the item (i.e., the edible items or token) in the participant's hand when the specific criterion is met for each condition. Session length and reinforcer amount will vary and is dependent on response persistence. One to five sessions will be conducted one to five days per week. Termination criteria will include (a) 1 min with no task completion, (b) completion of the last PR, or (c) 30-min.

Baseline. The baseline condition will be conducted identically to the baseline condition in the initial study with the exception of the instruction. The therapist will instruct the participant to complete the task (e.g., "If you match the pictures nothing will happen, but you can do whatever you want") at the start of the session. No additional programmed consequences (other than the consequences within the Boom Card application) will be delivered contingent upon correct or incorrect matching.

Paired Token. The paired token condition will be identical to the initial study with the exception of the instruction and the token board. The five-token token board that will be used during the token training (i.e., white rectangular token board with white triangular tokens; see Appendix D3) and the reinforcers will be placed on the table in view of the participant. The therapist will instruct the participant to complete the task to earn tokens for the back-up

reinforcer (e.g., “If you match the pictures, you will earn tokens that you can trade-in for treats, but you can do whatever you want”) at the start of the session. The therapist will deliver tokens contingent on the completion of a PR step. As in the initial study, one-trial MS preference assessment will be conducted when a reinforcer is earned and five pieces of the selected item (i.e., one for each token) will be delivered. The PR requirement will increase throughout the course of each session. Specifically, the PR requirement will increase after each token delivery. There will be no stimulus change when the PR requirement increase. Delivery of the reinforcer will reset the token board, and the next PR step will be initiated.

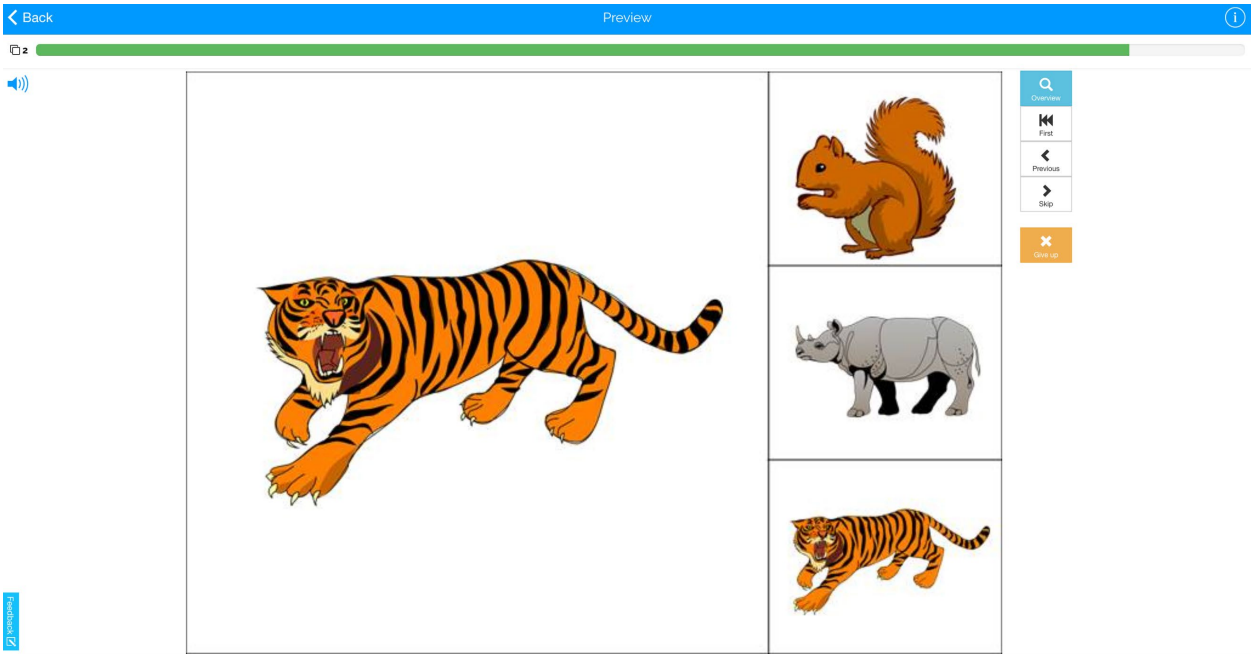
Primary Reinforcement. The primary reinforcement condition will be conducted similarly to the primary reinforcement condition in the initial study with the exception of the instruction. The reinforcers will be placed on the table in view of the participant. The therapist will instruct the participant to complete the task to earn a reinforcer (e.g., “If match the cards, you will earn treats, but you can do whatever you want”) at the start of the session. The experimenter will deliver a reinforcer contingent on the completion of a PR step. As in the initial study, a one-trial MS preference assessment will be conducted when a reinforcer is earned, one piece of the selected item will be delivered. The PR requirement will increase throughout the course of each session. Specifically, the PR requirement will increase after each reinforcer delivery. There will be no stimulus change when the PR requirement increases.

Unpaired Token. The unpaired token condition will be conducted similarly to the unpaired token condition in the initial study with exception of the instruction and the token board. As in the initial study, the unpaired token condition will be identical to the paired token condition, except a different token board will be used and the tokens will not exchangeable for back-up reinforcers. The therapist will instruct the participant to complete the task to earn tokens

(e.g., “If you match the cards, you will earn tokens, but you can do whatever you want”) at the start of the session. The unpaired token board will be different from the token board used during the paired token condition. The token board will be a black circular piece of laminated paper and the tokens will be black square pieces of laminated paper (Appendix D4). The unpaired token board will be placed on the table in view of the participant. The therapist will deliver a token contingent on the completion of a PR step. The PR requirement will increase throughout the course of each session. Specifically, the PR requirement will increase after each token delivery. There will be no stimulus change when the PR requirement increases. The participants will hand the therapist the tokens after the completion of the token board, which will reset the token board and will initiate the next PR step (i.e., no back-up reinforcers will be delivered).

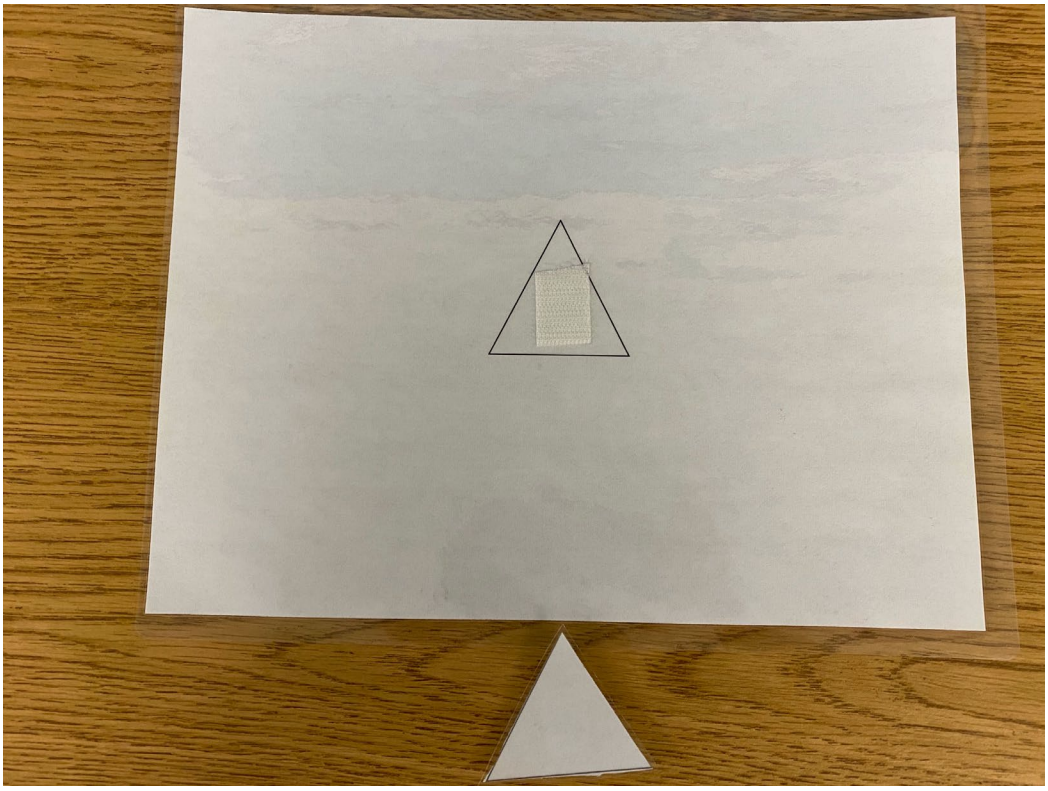
Appendix D1

Follow-Up Study: Boom Card Matching Task



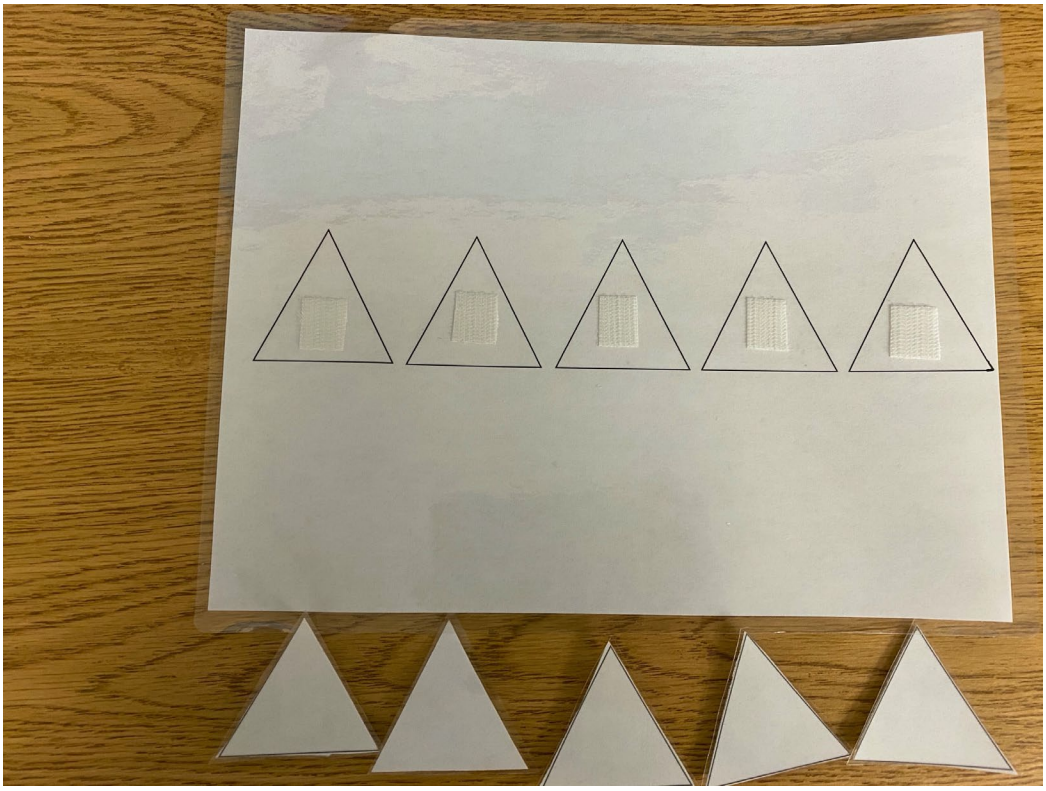
Appendix D2

Follow-Up Study: Token Training FR-1 Exchange-Schedule



Appendix D3

Follow-up Study: Paired Token Condition



Appendix D4

Follow-Up Study: Unpaired Token Condition