DISPLAYING RESPONDING WITHIN DIFFERENTIAL REINFORCEMENT PROCEDURES INCLUDING FUNCTIONAL COMMUNICATION TRAINING WITH DELAY:

A COMPARISON OF APPLIED GRAPHING APPROACHES

by

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(Under the Direction of JOEL RINGDAHL)

ABSTRACT

The purpose of this discussion article was to suggest an alternative form of statistical analysis and graphical presentation within differential reinforcement procedures, such as FCT, that include a delay to reinforcement component, the rationale for which is thoroughly examined in this thesis. These alternative graphing procedures offer contemporary solutions to increase the accuracy and efficacy of clinical treatment evaluation and decision making while limiting artifacts that occur due to common methods of response measurement used to increase a delay period. By including an accurate measurement for targeted alternative responding that can be displayed as a percentage the visual analysis of the graph is clearer to read and understand. Additionally, a measurement and display of response allocation ensures that the alternative communication response remains functional as the delay is increased.

INDEX WORDS: differential reinforcement; functional communication training; schedule thinning; delay to reinforcement

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CHAPTER 1

INTRODUCTION

It has been well established that individuals with developmental disabilities have a greater likelihood of exhibiting harmful problem behaviors, including a multitude of self-injurious behaviors and aggression, than their typically developing peers (Chezan et al., 2018; Kurtz et al., 2011; Tiger et al., 2008). The existing body of research on the emergence of problem behavior suggests that there are several possible reasons for this disparity. These reasons are comprised of both biological factors, such as Autism Spectrum Disorder (ASD), genetic predispositions, or other psychiatric conditions, as well as environmental factors. (Chezan et al., 2018; Kurtz et al., 2011). Though the biological cause of the development of such behaviors can vary drastically amongst individuals, the intervention for problem behavior must be as precise and accurate as possible to ensure that the individual learns to interact safely with his or her natural environment and the people within that environment (Chezan et al., 2018; Fox et al., 2002; Kurtz et al., 2011). Thus, the field of behavior analysis has established reinforcement-based treatment options which target the environmental factors which lead to problem behavior. While advancements have been made in the creation and implementation of these behavioral interventions, current research on the subject has not closely examined alternate ways in which these treatment data may be presented graphically and used in the clinical decision making processes.

Differential Reinforcement

There are several approaches to using differential reinforcement as a behavioral treatment, and it has become one of the most well-known and frequently utilized tools for reducing problem behavior (Cooper et al., 2007). Though there are four common approaches to differential reinforcement that each have a strong evidence base and many practical uses, differential reinforcement of alternative behavior (DRA) and differential reinforcement of incompatible behavior (DRI) are the two broad techniques used for reducing problem behaviors that this paper will address. These techniques involve delivering reinforcement contingent on a specific alternative response and withholding reinforcement for problem behavior, by placing that behavior on extinction (Cooper et al., 2007).

It is possible to have a successful DRI or DRA procedure which does not include extinction of the problem behavior, however, several studies have shown the absence of an extinction component often leads to less effective treatment (Athens & Vollmer, 2010; Cooper et al., 2007; Doughty & Anderson, 2006). The results of these studies indicate that larger and more steady reductions of problem behavior occur when extinction is included than when the problem behavior continues to be sporadically reinforced (Athens & Vollmer, 2010; Doughty & Anderson; 2006). While placing problem behavior on extinction is highly preferred for the best treatment results, parents and teachers may struggle with implementing extinction in the learner's natural environment, and it may not always be achievable (Cooper et al., 2007; Doughty & Anderson, 2006). Still, an attempt to limit reinforcement for the undesired behavior while increasing reinforcement for the desired behavior retains the potential for problem behavior reduction (Athens & Vollmer, 2010; Vollmer et al., 2020).

Though DRI and DRA are functionally very similar, the main difference between the two methods is that the highly reinforced behavior within a DRA program does not have to be a behavior that cannot occur in the presence of the lesser reinforced behavior. This is, however, the defining characteristic of a DRI intervention (Cooper et al., 2007). For example, if the problem behavior a practitioner wanted to reduce was screaming, the practitioner may reinforce whispering. As the two behaviors cannot occur concurrently, the learner is given two options for responding and must make the choice between them: the option which is frequently reinforced, or the option which will contact reduced reinforcement (Cooper et al., 2007). When implementing a DRA program, there is the possibility of the learner engaging in problem behavior and the alternative reinforced response simultaneously, though reinforcement is likely to be withheld in the presence of any problem behavior. Instead, the student is free to engage in any desired behavior, but there is an alternative behavior available that will reliably contact reinforcement and that can fill the time that is normally occupied by detrimental behaviors (Cooper et al., 2007; Vollmer et al., 2020).

Cooper et al. (2007) outlines several considerations to be made when choosing the incompatible or alternative behavior to be reinforced which increase the effectiveness of the DRI or DRA treatment and promote maintenance and generalization. First, the behavior must be one that the learner is already able to demonstrate. While it is possible to teach the alternative or incompatible behavior that will be targeted before beginning a DRI or DRA treatment, it is essential that the learner has shown mastery level with the skill or behavior that will be reinforced by the time treatment begins. Next, it is advisable that the behavior to be reinforced requires either similar or less response effort than the undesired behavior. The alternative or incompatible behavior must also be exhibited at a high enough rate before intervention is in

place that there will be frequent opportunities for reinforcement during treatment, and that there is a high likelihood for the behavior to contact reinforcement in the learner's natural environment following treatment.

Functional Communication Training

Out of all the differential reinforcement methods, one of the most popular (Tiger et al., 2008) and efficient (Greer et al., 2015) treatment options for challenging behaviors that are maintained by social reinforcement is known as functional communication training (FCT, Carr & Durand, 1985). FCT uses information gathered from a functional analysis (FA, Iwata et al., 1982) to identify the reinforcement that an individual is able to earn by engaging in problem behavior in his or her natural environment and subsequently using that same class of reinforcement to teach a less harmful and more appropriate behavior (Buckley & Newchok, 2005; Chezan et al., 2018; Falcomata et al., 2013; Hanley et al., 2014; Hagopian et al., 2011; Muharib & Pennington, 2019; Tiger et al., 2008). FCT can be thought of as a derivative of the differential reinforcement of alternative behavior (DRA) schedule of reinforcement, though because of FCT's explicit association with an individual's FA results, it has some unparalleled advantages over a non-function based DRA schedule (Betz et al., 2013). The link between FA results and an FCT treatment allows for an individualized approach which not only increases an alternative behavior and decreases problem behavior but also reduces the establishing operation (EO) which was maintaining the problem behavior by allowing the individual to regularly come into contact with the functional reinforcer and involves the use of a recognizable form of communication that has the ability to be generalized across multiple contexts (Betz et al., 2013; Falcomata et al., 2013; Hanley et al., 2014; Hagopian et al., 2011; Muharib & Pennington, 2019; Tiger et al., 2008).

Functional Communicative Responses and Manding

The alternative response which is reinforced during treatment is referred to generally as a mand, or as a Functional Communication Response (FCR) in the context of FCT (Falcomata et al., 2013; Muharib & Pennington, 2019). Mands are always maintained by a particular reinforcer, but the topography of the mand can be tailored to the preferences and requirements of the individual (Falcomata et al., 2013). Most often, vocal mands, mands using picture exchange systems, gestural or sign language mands, or mands using a communication device are targeted as the substitute for more detrimental behaviors that an individual may exhibit (Falcomata et al., 2013; Muharib & Pennington, 2019; Tiger et al., 2008). Because there are so many routes to functional communication available, it is important to take into account an individual's ease of responding when it comes to selecting the FCR that will be targeted during FCT, as some studies have found that increasing the response effort of a targeted mand could lead an individual to revert back to using problem behaviors in an attempt to contact reinforcement (Buckley & Newchok, 2005; Cagliani et al., 2017). Once the reinforcer for the problem behavior is established and an appropriate FCR is identified, the training of the new response can begin with reinforcement available solely contingent on the FCR, and with problem behavior placed on extinction (Falcomata et al., 2013; Tiger et al., 2008).

Challenges of Functional Communication Training

Though previous research has established that FCT is effective at increasing socially appropriate communicative responding while decreasing rates of problem behaviors, implementing the use of FCT outside of a clinical setting comes with several challenges (Falcomata et al.; 2013; Hanley et al., 2014; Muharib & Pennington, 2019; Tiger et al., 2008).

First, FCT requires a highly attentive communication partner, who may be a therapist, teacher, or parent. In a clinic there may be a therapist who has the ability to reinforce every FCR emitted by a single individual, but the same is not likely to occur in other contexts such as school or at home, where other people may require attention from the individual's communication partner and where other distractors are likely to be present (Hagopian et al., 2011; Muharib & Pennington, 2019). If the response effort becomes too great for the communication partner or if situations arise in which it is not feasible for the FCR to be reinforced immediately, reemergence of problem behavior may occur (Betz et al., 2013; Hagopian et al., 2011; Muharib & Pennington, 2019).

Additionally, in educational settings, another issue can arise. If escape from work is used as the reinforcer for engaging in the FCR, a student may choose to mand for a break every time a demand is placed. In this case, the student could fall far behind in their academic progress which would soon become an issue, even if the challenging behavior they were previously engaging in ceased to occur (Betz et al., 2013; Muharib & Pennington, 2019).

Procedures for Thinning a Delay to Reinforcement

To address these issues, incorporating a schedule thinning procedure into an FCT, DRA, or DRI program is a crucial step to promoting the practicality of the individual's communicative responding to their natural environment (Betz et al., 2013; Falcomata et al., 2013; Muharib & Pennington, 2019; Tiger et al., 2008). While it is possible to thin by a chained schedule or a multiple schedule of reinforcement and both have useful and practical applications, delay to reinforcement schedules most closely emulate a natural environment wherein reinforcement may not always be accessible to the learner the instant it is requested (Hagopian et al., 2011). However, it is important that the decisions regarding increasing the delay between the request

and reinforcement are data driven and consistently evaluated, as the relationship between the two may become weaker as the delay is increased (Hagopian et al., 2011).

In Hanley et al. (2014) and Muharib and Pennington (2019), the authors discuss very similar procedures for how a tolerance response for delay was taught within their FCT program in addition to the FCR which remained in place. They used Behavioral Skills Training (BST) to teach their participants a socially valid response, in this case saying "okay" and taking a breath, to being told "no" by an adult after the child engaged in the FCR. The majority of studies, such as Stevenson et al. (2015) and Roane et al. (2004), do not include the training of a specific wait response in their schedule thinning protocols.

Hanley et al. (2014) initially reinforced the individual's behavior directly after he or she produced the tolerance response, but progressively, the delay between the tolerance response and the reinforcement was increased if problem behavior did not occur and FCR did not require prompting. The participants in this study were expected to either participate in a less preferred activity, to tolerate redirection, or to follow adult instruction. During the baseline sessions for denial, rates of problem behavior increased for all three participants. However, during the tolerance to denial training sessions, problem behavior decreased to almost zero levels once again. Nonetheless, the rate of FCR for every participant showed a consistently decreasing trend across sessions, and no information was provided regarding whether FCR occurred solely when it would contact reinforcement or if FCR also occurred during the delay or reinforcement periods.

Fisher et al. (2000) had a similar approach to their procedures. In one experiment, after FCT with extinction was taught and mastered, the authors continued to target three of the participant's harmful behaviors and introduced a delay component. They slowly increased the

delay between FCR and reinforcement if the combined rate of all three problem behaviors remained 95% below baseline levels for five successive sessions. During these sessions, access to toys was available. In another similar experiment within the same article, the learner began with a delay to reinforcement of two seconds, which increased if the rate of the individual's problem behaviors stayed under 90% of their baseline levels. Initially, progress was slow and inefficient for this participant as they saw an increase in addition problem behaviors during the wait period. However, after they introduced a demand component during the session and demands were removed during the wait period, a ten-minute waiting period was achieved. The graph of FCR in the first experiment shows an immediate decreasing trend for communication as well, with the last data points at near-zero levels. Still, the participant continued to engage in FCR during the sessions, though whether FCR only occurred when reinforcement was available was unspecified in this article. Unfortunately, the graphs for FCR during the delay sessions were not presented for the other experiment.

Roane et al. (2004) thinned the delivery rate of reinforcement in a different way. The participants were taught to respond by touching a card during the initial stages of FCT to contact reinforcement. When the delay component began, practitioners restricted access to the response card for 3 s, then 5 s, then 10 s. From there, they continued to double the restriction period after two sequential sessions with rates of problem behavior that were 80% or lower than their baseline levels. Each participant reached the terminal delay of 320 s. Once again, even though FCR continued to occur in the later sessions for both participants, both graphs show a decreasing trend for FCR as the delay period was increased and again, did not specify when the FCR occurred within the session.

In the case of Stevenson et al. (2015), once problem had decreased and the rate of FCR had increased to a desirable level, a variable interval (VI) schedule was introduced wherein after the individual engaged in FCR, he was told "you have to wait for now" or "you cannot have that right now," and then was redirected towards activities that were currently available. The timer started immediately after his first mand, and once he manded again after the preset interval ended and he was able to contact reinforcement. After three consecutive sessions without problem behavior, the preset interval was systematically increased. The data from this study were graphed in a similar manner to the others, but problem behavior and mands were shown as a frequency instead of rate. Still, the artifact of a downward trend in mands could be observed as the wait intervals increased and the opportunities for FCR decreased and mands were combined graphically, whether they were truly functional or not.

Purpose

The ultimate aim of this discussion article is to bring attention to an uncommonly used method of graphically presenting functional communication responses or other alternative behaviors within a differential reinforcement with delay treatment package. This project was undertaken to provide practitioners and researchers with additional tools for collecting, analyzing, and presenting treatment data. Though the general concept of graphing FCT with delay data as a percentage has appeared in the literature at least one other time, as a supplemental post-treatment display in Hanley et al. (2001), it has not yet been employed as a method of clinical decision making. This method allows practitioners to increase delays to reinforcement contingent not only on the frequency of problem behavior, but also on the participant's stability of responding in order to decrease the likelihood of problem behavior reoccurring. The addition of a graphic display based on the participant's response allocation during the different

components of a session allows for further reassurance that alternative responding is being used functionally by the individual. Also, the application of this concept has yet to be expanded into further areas of research, such as within differential reinforcement of alternative behavior and differential reinforcement of incompatible behavior.

CHAPTER 2

RATIONALE

Once the alternative, incompatible, or functionally communicative response has been well established, the process of thinning the schedule of reinforcement should begin (Cooper et al., 2007). However, to thin this schedule in a way that is behavioral in nature, the behavior under investigation must be measured meticulously. The measurement must ensure that the information captured is representative of the participant's behavior alone and is not sensitive to the behavior changes of the behavior's observers (Baer et al., 1968; Cooper et al., 2007). Further, the methods leading to the alteration of behavior as well as any possible explanations for the source of the behavior change ought to be able to be explained in terms of the variables involved in the treatment (Baer et al., 1968; Cooper et al., 2007). Specifically, data collection, measurement, and the visualization of such information must be centered around the behavior which is affected by the treatment (Cooper et al., 2007).

Yet, with a DRI or DRA schedule of reinforcement, the behaviors targeted are two separate behaviors that are expected to change concurrently (Cooper et al., 1997; Fisher & Mazur, 1997). As the appropriate responding increases due to more favorable schedules for that response, the number of opportunities to engage in problem behaviors that no longer contact dense reinforcement decrease. Though this is development is anticipated, it is possible for a participant's behavior to subvert this expectation, and for other unforeseen variables to be responsible for either a reduction in problem behavior or an increase in appropriate responding.

For instance, a FCT with extinction and delay treatment may be in place wherein signing "more" is the alternative response which contacts tangible reinforcement to self-injurious head banging which is placed on extinction. A reduction in problem behavior is seen, but manding never increases from baseline levels and takes place evenly throughout the session, including during reinforcement. Meanwhile, the reinforcement delay continues to be increased after several sessions with low levels of head banging. Although the decrease in self injury was the desired outcome, there is no reason to believe that the FCT treatment is what changed the behavior as the rates of FCR showed no relationship between the alternative response and the problem behavior. Though the level of FCR may have been stable, all FCRs should take place exclusively, or almost exclusively, while the relevant EO is present during an effective treatment. Therefore, the FCR emission should strongly favor the portion of the session where the EO is present as opposed to the reinforcement intervals or delay segments.

Similarly, in DRA procedures where it is possible to engage in both the alternative behavior and the problem behavior simultaneously, the treatment could not be considered successful if decisions were made solely based on increased alternative responding without respect to the changes in problem behavior. In DRI procedures, measuring and analyzing problem behavior exclusively could have a similar effect if an extra experimental variable is suppressing problem behavior. Consequently, in DRA and DRI the practitioner is obligated to collect directly measured and frequently evaluated data on both the individual's undesired behavior and the targeted appropriate response to detect and respond to behavior changes (Cooper et al., 2007).

CHAPTER 3

OPTIONS FOR GRAPHING DIFFERENTIAL REINFORCEMENT WITH DELAY

Common Methods

The most common way to graph FCT, DRA, or DRI with delay data has been as the rate of mands or functional communication responses per minute (e.g., Fisher et al., 2000; Hanley et al., 2014; Roane et al., 2004) though some have graphed these data as count (e.g., Stevenson et al, 2015). Data graphed using these methods have shown a basic variability of responding, but they have often displayed a decrease of the FCR response as the number of sessions increased. This decrease occurs because as the delay to reinforcement increases, the session time remains stable and there are fewer opportunities for an individual to produce the FCR in a session, thus the graph shows a decrease in mand rate. However, the lack of mands during the reinforcement period when there is no establishing operation and during the delay period in which the individual is made aware that FCR will not contact reinforcement should be seen as a consequence of a successful intervention. Thus, data indicating when FCR occurs during session, such as when the EO is present, during the delay period, or during the reinforcement period, should also be represented graphically and this information should be used to further evaluate the effects of the treatment.

One common way to graph FCT outcomes is to display rate of FCR on one axis displaying the level of problem behavior on the other axis such as in Figure 1 (e.g., Fisher et al., 2000) or as completely separate graphs with the same axes (e.g. Hanley et al., 2014; Roane et al., 2004). The data presented in Figure 1 was adapted from an FCT with extinction and delay

treatment package designed for an individual who engaged in multiple topographies of problem behavior within the same response class multiple times a day. The criteria for increasing the delay between FCR and reinforcement was three sessions without problem behavior, though because the data were graphed post-session, there is one instance during the 5s delay in which the delay was mistakenly increased after only two sessions without problem behavior.

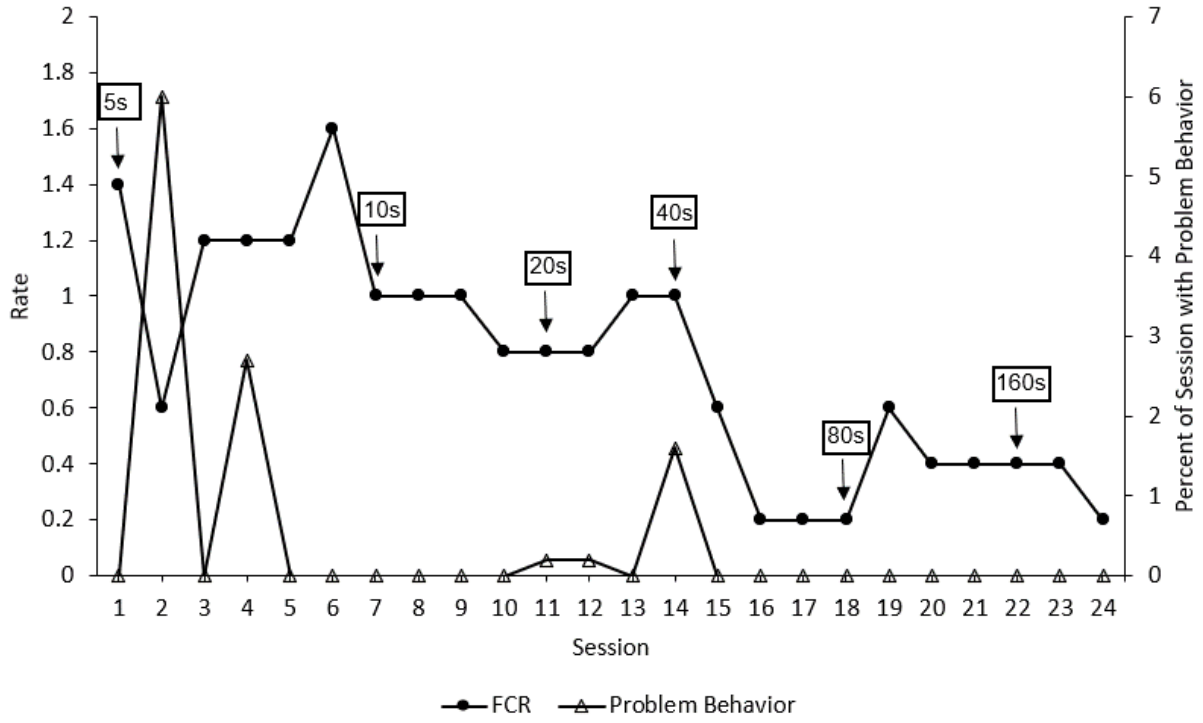

Figure 1. Graph of FCR as Rate. Displayed on the left vertical axis is the percentage of opportunities with communication and problem behavior is displayed on the right vertical axis as the percentage of session with problem behavior. Arrows indicate the session in which the delay was increased and the number of seconds in the delay period.

NOTE: FCR = Functional Communication Response

Alternative Methods

As an accompanying calculation to the original data used during treatment, Hanley et al. (2001) graphed a measure of responding by percentage. The number of reinforcers earned was divided by the total number of alternative responses during a session and then multiplied by 100

to get a percentage to examine the participant's efficiency of responding. Graphed using this method, the authors discovered that the participant was frequently responding through the session even when reinforcement was present, indicating that the addition of a delay component weakened the relationship between the response and reinforcement. This method can be useful if an individual is observed to be responding at very high rates throughout the session, but it does not account for the possibility that an individual may produce the FCR in quick succession while the EO is present, as all responses are considered equally. However, there is another method of calculating alternative responding that can give a more precise picture of the participant's behavior, particularly if responding is only occurring when the EO is present, as it should be at the time the delay is introduced. This method also includes a measurement of the appropriate responses that occur after the last opportunity for reinforcement but while the session is still running. Still, data should be collected on all alternative responding, and in an effective treatment the allocation of the FCR within each session should occur far more often during the component where the establishing operation is present (EOP) than the delay or reinforcement components.

To display this information, a bar graph of the proportion of responses during each component can be used. The number of FCR responses is broken up by component, and the number of FCR in each component is divided by the total number of FCR during the session to find the proportion of FCR during the EOP components, delay components, and reinforcement components. For the first session in the example Figure 2, which adapts data from the same participant and treatment used Figure 1, six out of seven (6/7), or 0.857, of the responses

occurred during the EOP component, with one out of seven (1/7), or 0.143, occurring during the reinforcement period, and no responses occurred during the delay period.

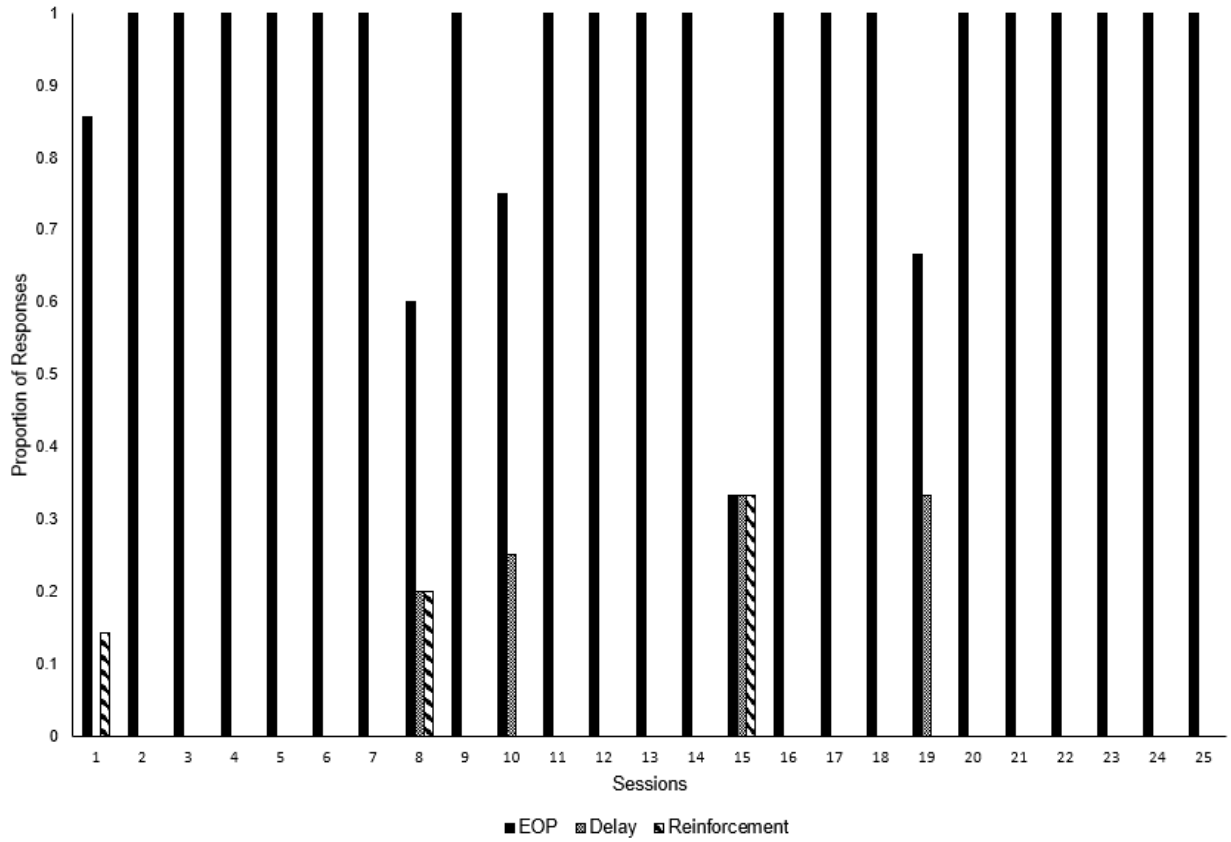

Figure 2. Graph of Proportion of Responses by Component. Displayed on the vertical axis is the proportion of responses in the EOP, Delay, and Reinforcement components by session.

NOTE: EOP = Establishing Operation Present

Analyzing alternative responding as a percentage can be achieved by first calculating the number of appropriate responses that it would be possible for the learner to produce during the session. To calculate this, the session time is divided by the amount of time taken by reinforcement and delay, and that number is subsequently rounded up to the nearest whole number so that number of functional appropriate responses that occur at the tail end of the session can be included. The frequency of functional responses, or the responses that contacted

reinforcement, within the session is then divided by the number of potential responses and multiplied by 100 to get a percentage of responding. So, to compute the first point of the graph using the same data from Figure 1, we would use the following calculation: 300 s/(30 s+5 s) = 8.57. 8.57 rounded up is nine total opportunities and the actual number of responses was seven, so 7/9 = 77.78%. Problem behavior can be graphed on the right axis as the percentage of session in which it occurred. Figure 3 shows the same data included in Figure 1 graphically expressed using this method of calculation.

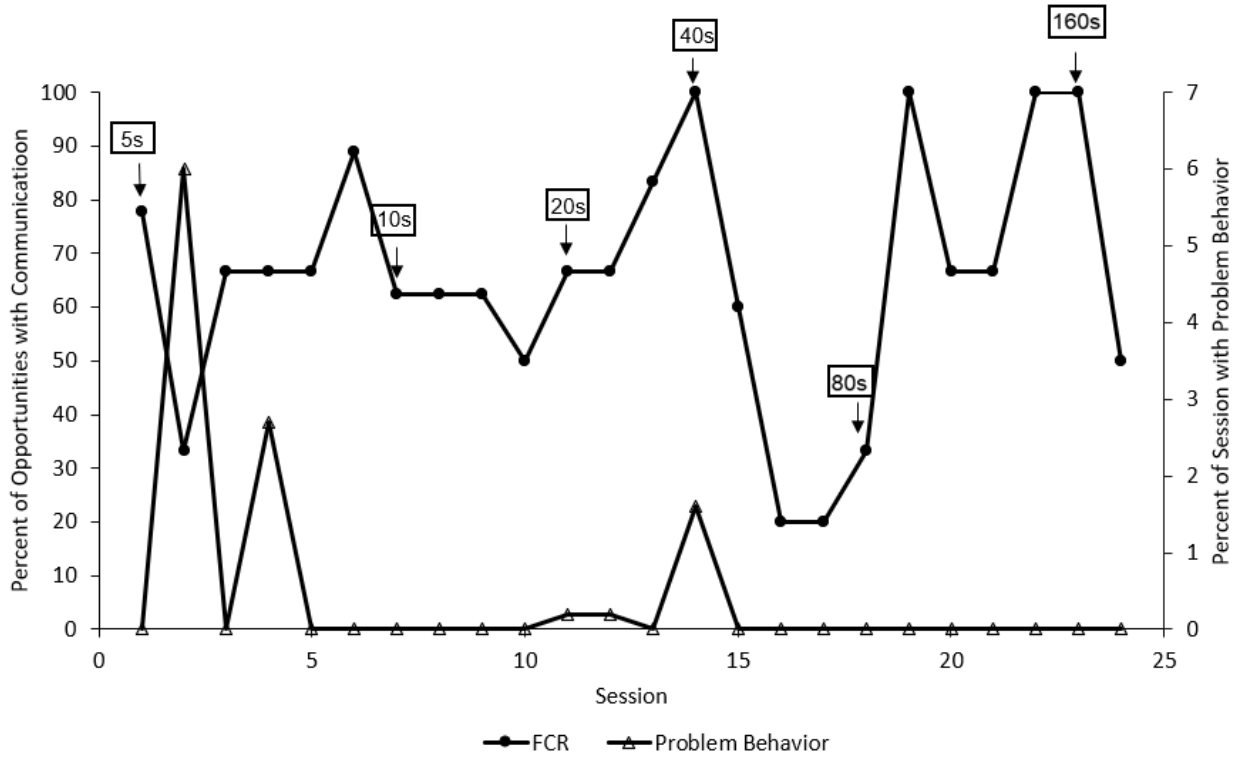

Figure 3. Graph of FCR as Percentage. Displayed on the left vertical axis is the percentage of opportunities with communication and problem behavior is displayed on the right vertical axis as the percentage of session with problem behavior. Arrows indicate the session in which the delay was increased and the number of seconds in the delay period.

NOTE: FCR = Functional Communication Response

CHAPTER 4

DISCUSSION

Implications

The approach of graphing targeted appropriate responses as a percentage in DRA, FCT, and DRI treatments with delay components is not only a useful tool for research and for analyzing the results of a treatment, but also can have valuable practical applications for clinicians. Although most studies increase the delay between the alternative response and reinforcement by the exhibition of problem behavior, by not including continued rates of high responding in the criteria for increasing the delay it becomes possible for an individual to engage in appropriate responding very infrequently as the delay is continuously increases. This would cause the FCR to be rarely reinforced and the individual could revert to engaging in problem behavior, which may be incidentally reinforced at a much higher rate in the individual's natural environment. Figure 3 includes fictional data based on the data used in Figures 1 and 3 and is a projection of what treatment data may resemble using 80% of potential FCR and no problem behavior as the criteria for increasing the delay.

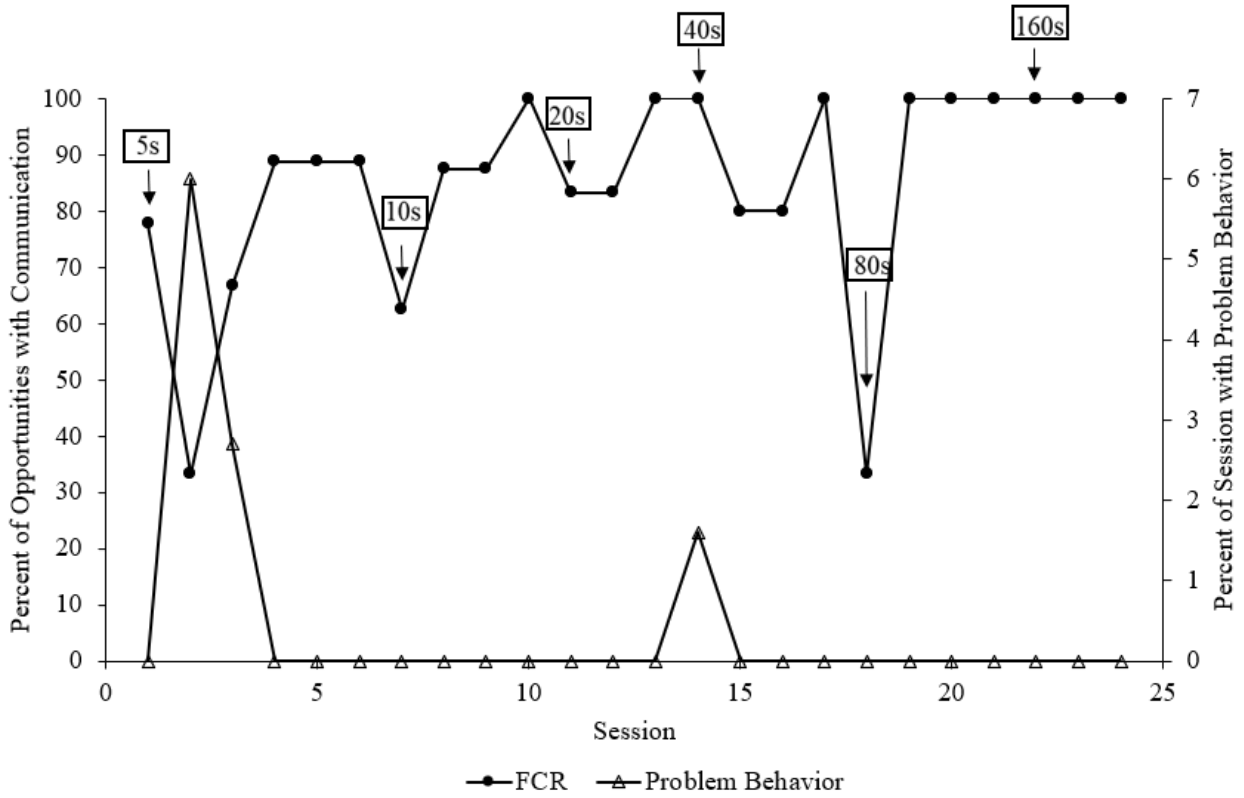

Figure 4. Graph of Projected Use: Fictionalized Data. Displayed on the left vertical axis is the percentage of opportunities with communication on the right vertical axis is problem behavior as the percentage of session with problem behavior. Arrows indicate the session in which the delay was increased and the number of seconds in the delay period.

NOTE: FCR = Functional Communication Response

Additionally, by not displaying information regarding when the FCR is occurring, it is possible for an individual to continuously engage in FCR throughout the reinforcement and delay periods without the practitioner knowing, if only whole-session data are considered. This would mean that the individual was not using the FCR response functionally, and the delay would continue to be increased regardless. In Figure 2, the individual displayed high levels of allocation during the EOP component and low levels of allocation toward the other two components, which suggests that the individual maintained a strong connection between the FCR and the

reinforcement even as the delay increased. By neglecting to include stability of responding and response allocation as well as problem behavior when graphically representing FCT with delay treatment data or other similar data, important aspects of the participant's behavior and responses to treatment can be entirely missed.

Limitations

While this technique could be useful for DRA and DRI procedures, it cannot be directly applied to other differential reinforcements procedures such as differential reinforcement of other behavior (DRO) or differential reinforcement of low rates of behavior (DRL). Still, a DRO or DRL can be graphed as the percent of successful intervals, which could be visualized using methods similar to those outlined above and provide meaningful information about the participant's learned behaviors. However, the aforementioned techniques are also more complex to graph than the traditional rate of problem behavior method and may make data collection more complicated. Also, data would likely have to be updated graphically in order to be confident that it meets the contingencies for alternative responding and the contingency for problem behavior before increasing the delay period. Lastly, some individuals will not produce the FCR at or near a 100% level. The method of graphing the percentage of opportunities with communication can still be used, but it is important to use the individual's FA results and to find their percentage of problem behavior during those sessions in order to set a realistic criteria for the FCR.

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