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THE CURRENT STATE OF DIFFERENTIAL REINFORCEMENT: A BRIEF REVIEW AND ANALYSIS

Alex Kerby[1]
Graduate Student

T. F. McLaughlin[2]
Full Professor
Department of Special Education
Gonzaga University

Abstract: *The topic of this literature review will be the review of the current literature on differential reinforcement. The various forms reviewed included: Differential Reinforcement of Other Behavior, Differential Reinforcement of Alternative Behavior, and Differential Reinforcement of Incompatible behavior. Other types of differential reinforcement, such as Differential Reinforcement of High-rates and Low-rates, will be included, but only to discuss why a comparison is not appropriate. This literature review will attempt to cohesively summarize the literature on different forms of differential reinforcement while explaining each. In addition to this, a brief historical overview of differential reinforcement will be given.*

Key Words: *Differential reinforcement, DRO, DRA, DRI, DRL, DRH, reinforcement, aberrant behaviors, positive procedures, behavior change, reducing behaviors*

Introduction

The use of differential reinforcement has a long history. According to Lejeune, Richelle and Wearden (2006), the first instance of differential reinforcement was presented in Skinner's 1938 book, *The Behavior of Organisms: An Experimental Analysis*. Although unnamed at the time, Skinner (1938) discussed Differential Reinforcement of Other (DRO) behaviors. In this instance, the target behavior to be put on extinction was a response within 15 seconds of a stimulus. The target behavior to be reinforced was any response after 15 seconds.

There are multiple types of differential reinforcement procedures, but they all share the same basis principle. The basic components of any differential reinforcement procedure are the extinction of a target behavior and the reinforcement of a different behavior (Legray, Dufrene, Sterling-Turner, Olmi & Bellone, 2010). The procedures to be covered in detail in this literature review are Differential Reinforcement of Other (DRO) behaviors, Differential Reinforcement of Alternate (DRA) Behaviors and Differential Reinforcement of Incompatible (DRI) behaviors (Cooper, Heron, & Heward, 2007).

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In addition to the three main types of differential reinforcement, there are three more, which are not appropriate to include in this literature review. The first is Differential Reinforcement of High-rates (DRH) (Cooper, et al., 2007). This procedure involves only reinforcing rates of behavior that occur above a preset level (Cooper et al., 2007). The second is Differential Reinforcement of Low-rates (DRL). This procedure involves only reinforcing rates of behavior that occur below a preset level (Cooper, et al., 2007). The third is Differential Reinforcement of Diminishing Rates (DRD). This procedure only reinforces rates of behavior lower than a previous criterion over a given time period (Cooper et al., 2007). The reason these three procedures will not be included is that the focus of each is on changing rate. While this is an alteration in behavior that requires the extinction of one aspect and the reinforcement of another, it is the same behavior.

Methodology

While gathering material for this literature review, a number of resources were used. The vast majority of the articles came from electronic databases. The reason for this is threefold. The first is that these databases allow a user to search large amounts of journals in short periods of time. The second reason is that search filters allow a user to filter through a host of journals and find only the journals that are peer reviewed and relevant. The third reason is electronic databases allow a user to quickly access other works referenced in an article. This allows the researcher to collect a quick snowball sample of the available literature. The databases used extensively for this literature review were Academic Search Complete (EBSCO) and Google Scholar. In addition to these electronic resources, the text, *Applied Behavior Analysis (2nd ed.)* by Cooper et al. (2007) was employed. This text served as a basic foundation for all the general descriptions of techniques. However, the book lacked applied experiments and research. Studies were often cited but rarely covered in any detail. While the book lacked experiments and research, there were ample articles available that dealt with all kinds of differential reinforcement.

Review of Literature

Effectiveness of Differential Reinforcement

Differential reinforcement is a widely known technique, so much so, that more recent articles often neglect a proper discussion and explanation of the principles and positive aspects of the procedure. In their 1990 article, Cowdery, Iwata and Pace discuss differential reinforcement; it's positive attributes and conducts an experiment to demonstrate its effectiveness. In the introduction, Cowdery et al. (1990) assert that, in addition to being widely used and known, differential reinforcement is also less intrusive than any other behavioral intervention. The authors state two main reasons for this. The first reason is that a differential reinforcement procedures use no positive or negative punishment. The second reason is that they do not require the use of time-outs. The authors state that despite the popularity of differential reinforcement

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and it's positive attributes, it is not clear whether it is actually an effective treatment for problem behavior. The purpose of their study was to demonstrate that differential reinforcement was an effective behavioral intervention for Self-injurious Behavior (SIB). At the time of the Cowdery et al. (1990) article, very few studies had shown positive results using differential reinforcement to treat SIB (Cowdery et al., 1990). The participant in the study was a 9-year-old boy who's SIB was so severe it kept him from attending school, despite having a normal IQ. The authors noted that multiple interventions had been attempted but none had been successful. The most effective intervention attempted was positive punishment, in the form of an icepack being applied to the injured area. However, even this intervention had only reduced the SIB by 30%. As the result of a functional analysis, the SIB for this child was found to be automatically reinforced. The differential reinforcement procedure chosen was DRO, with tokens being the chosen reinforcer. The participant was left alone in a room and told that if he did not engage in SIB while the therapist was gone, he would receive a token. Initially, the time he was left alone was 2 minutes and was gradually increased to 30 minutes. As the time was increased, so was the amount of tokens received for not engaging in SIB. The procedure resulted in an alone time of 30 minutes with very low to zero SIB, depending on session. Due to the success of this initial procedure, a second phase was conducted. The second phase consisted of 30 minute, or longer, sessions of DRO. A timer was set for 30 minutes and if at the end of the interval, no SIB occurred, the participant received a token. However, if SIB occurred during the 30-minute interval, the timer was reset and no token was received. This phase also proved successful and a third phase was implemented. This phase involved the DRO procedure being extended to all hours of the day. Also, due to the success of the DRO procedure, the third phase also involved training the participant's parents to use the procedure at home. The authors write that this was the first time the participant had been discharged from his care facility in 2 years (Cowdery et al., 1990).

The results of this study present a convincing case for the effectiveness of differential reinforcement procedures in treating SIB. The procedure was not only effective at reducing SIB; it did so quickly and without side effects. However, the authors note that their findings have limited generality to other clients and situations.

Differential Reinforcement of Other Behaviors

DRO was the first differential reinforcement procedure ever developed (Lejeune et al., 2006). It is also arguably the easiest to implement. With other differential reinforcement procedures, such as DRA and DRI, the practitioner must watch for multiple behaviors. With DRO, reinforcement is delivered in the absence of the target behavior. During the DRO sessions, any other behavior besides the target behavior is reinforced (Cooper et al., 2007). For example, in the Cowdery et al. (1990) article, as long as the participant did not engage in SIB, any other behavior he did during those sessions was subsequently reinforced. There are two main types of DRO, one requiring very little monitoring. The first, as used in the Cowdery et al. (1990) article, is interval DRO. This type of DRO requires the problem behavior to be absent for the entire interval. If the

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problem behavior occurs, no reinforcement is earned and the interval starts again (Cooper et al., 2007). Another more recent article focusing on interval DRO is the 2004 article by Flood. In this study, the author examined the effects of interval DRO to increase time away from a caregiver. The participant in this study was an 11-year-old boy. The purpose of the intervention was to incrementally increase the time that the participant could spend away from his caregiver before engaging "emotional behavior" (Flood, 2004). Emotional behavior was defined as whining, crying or any vocalizations indicating the desire to see his caregiver. For this study, the time between the caregiver leaving and an emotional behavior response was measured. The participant was reinforced with preferred tangibles whenever emotional behavior was absent for a session. Initially, the participant would engage in emotional behavior while the caregiver was leaving. The shortest session length was three minutes. The time away from caregiver was doubled each time the participant went 2 or 4 sessions without displaying any emotional behavior. The final session time was 90 minutes. In addition to time spent away, caregiver distance was also measured. In the beginning sessions, his caregiver only felt comfortable 10 feet outside the room. This distance was gradually increased until the caregiver could actually leave the premises for the entire 90-minute session.

This study had several of strengths. The first was the successful application of interval DRO to increase the time the participant spent away from his caregiver. The author writes that before intervention, it was extremely rare the caregivers could spend anytime apart from the participant. Only in emergency situations did they separate. Initially, the participant would exhibit emotional behavior while his caregiver was leaving and immediately after their departure. Following treatment, the participant could spend 90 minutes alone with no emotional behavior. The second strength was the lack of emotional behavior throughout treatment. With the exception of one session, there were no instances of emotional behavior during treatment. Another strength was the inter observer agreement (IOA). Typically, IOA is not calculated on all sessions. Cooper at al. (2007) suggests IOA should be calculated on at least 20% of the sessions. In this particular study, not only was IOA 100%, it was also calculated on 100% of the sessions (Flood, 2004).

There is a second type of DRO called momentary DRO. Momentary DRO allows reinforcement to be delivered as long as the problem behavior is absent at the moment the interval ends. Each of these variations of DRO has their benefits. Some studies have shown interval DRO to be more effective. One advantage that momentary DRO has over interval DRO is the effort it takes to implement. In some situations, monitoring for the entire session is not practical. While using momentary DRO, the practitioner only has to monitor the client for the exact moment the interval ends (Cooper, et al., 2007). There may also be other applications of momentary DRO, other than primary intervention. In the 1986 article by Barton, Brulle and Repp, the authors investigated the use of momentary DRO to maintain low problem behaviors after an initial intervention with interval DRO. The initial experiment actually compared momentary DRO to interval DRO as a primary intervention. The authors state that interval DRO proved to be a much

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more effective primary intervention. However, during their initial study they speculated that momentary DRO could be used to maintain the progress they had already seen with interval DRO. This hypothesis set the stage for an experiment using 9 participants, each needing treatment for various aberrant behaviors. The 9 participants were separated into three groups of three. There were three different conditions. The first was A, or baseline. The second was B, which consisted of interval DRO. The third was C, which was momentary DRO. Each of the three groups participated in a different type of experimental design. The first was an ABC design, the second was an AB, and the third was an ABAB. These three designs allowed a comparison of maintenance with momentary DRO, interval DRO and baseline. The results showed that, not only was interval DRO effective in reducing problem behavior, momentary DRO was just as effective as at maintaining low rates of problem behavior. The results also showed that a return to baseline showed a quick increase in the rates of problem behavior. The results of this study were important for two reasons. The first is that they add to the literature supporting differential reinforcement as an effective treatment. The second is that the study showed low rates of problem behavior can be maintained momentary DRO. This is important to practitioners and educators because momentary DRO is significantly easier to implement (Barton et al., 1986).

Differential Reinforcement of Alternative Behavior

Successful applications of DRA have some of the best outcomes of any of the differential reinforcement procedures. While more complicated than other differential reinforcement procedures, DRA produces two desired outcomes. First, it lowers the rate of the target problem behavior. Its second outcome is also what sets it apart from other differential reinforcement procedures in terms of desirability of outcome. DRA teaches an alternate and appropriate replacement behavior for the problem behavior that is to be put on extinction. One recent example of DRA being successfully implemented is the study by Sira and Fryling (2012). The participant in this study was one 9-year-old boy diagnosed with autism. The problem behavior to be put on extinction was food refusal and the alternative behavior to be reinforced was eating non-preferred foods. This study was conducted in the participant's home and also made use of peer modeling. The treatment consisted of the participant's younger sister first eating a bite of the target food. When the participant's sister successfully ate the food, she was provided with social praise. The participant was then presented with a bite of the same food. If the participant ate the food, he was reinforced with social praise. If not, the food refusal was ignored and it became the participant's sister's turn to eat again. The intervention was initially completed by a therapist and later the participant's parents. This procedure was also completed with three different types of food. The first food was spaghetti. During baseline, the participant ate 0% of the spaghetti presented. He ate 88% of the spaghetti presented during treatment and 90% at a two-month follow up. The second food was hamburger. During baseline, the participant ate 0% of the hamburger presented. However, during treatment the participant ate 93% of the presented

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hamburger and ate 100% at a 2-month follow up. The third food was scrambled eggs. During baseline, the participant consumed 0% of the scrambled eggs presented. During treatment, his consumption of scrambled eggs averaged 82% and 100% at a 2-month follow up. This study is important for two main reasons. It is a demonstration of DRA being successfully used to treat food refusal. It is also an example of treating food refusal without escape extinction. Most of the research regarding food refusal suggests that escape extinction may be an essential part of treating food refusal. However, this study provides an example of successful use of a DRA procedure to treat food refusal without the use of escape extinction (Sira & Fryling, 2012).

One of the negative aspects of DRA is the increased effort of implementation over other differential reinforcement. One study by Roane, Fisher, Srgo, Falcomata and Pabico (2007) explored methods for thinning the reinforcement schedule to allow easier continuation of the DRA procedure. In this study, there were two participants in a 5-day a week outpatient clinic. Both of the participants were boys, ages 7 and 11, and diagnosed with autism and mental retardation. Data was collected on the behaviors of the participants and the therapists. Aggression and manding were recorded for the participants and reinforcement delivery was recorded for the therapists. Inter-observer agreement (IOA) was high (range 96-100%) but was only calculated on 21% of the sessions for one participant and 27% for the other. A functional analysis was completed for each participant and showed their aggression to be maintained by attention and tangibles. Due to these results, DRA was implemented to teach alternate attention or tangible obtaining behaviors. Where this study differs from previous literature is with the implementation of a thinning schedule. Each participant's alternative behavior was to use a card to mand for his or her desired reinforcer. Initially, whenever the participants used the break card, they received their respective reinforcer. Following establishment of the card, the schedule was thinned from a continuous reinforcement schedule to a 320 second delay. The delay was gradually increased 5 seconds every two uses of the cards, in a period with less than 80% of the problem behavior observed in baseline. The results showed an increase in appropriate behavior and a decrease in problem behavior. Most importantly, the low rates of problem behavior were maintained even on the thinned schedule.

While this study had plenty of strengths, there was one weakness. Although IOA was high, it was only calculated on 21% of the sessions for one participant and 27% for the other. These numbers are just barely above the minimum suggested by Cooper et al. (2007). Overall, this study adds an important contribution to the available literature on DRA. It shows that one of the negative aspects of DRA, difficult implementation, can be mitigated by the use of thinning reinforcement schedules.

Comparison of DRA and DRO

The previous two differential reinforcement procedures each have positive and negative aspects and situations in which they are better suited. A recent article by LeGray, Dufrene, Sterling-

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Turner, Olmi, and Bellone (2010) directly compares the effectiveness of DRO and DRA. The study had three participants, all in preschool or kindergarten and referred for behavior problems. The authors used an alternating treatments design to directly compare DRO, DRA and a control group. The behavior to be put on extinction was inappropriate vocalizations and, for DRA, the behavior to be reinforced was appropriate vocalizations. Results from this study indicate that DRA was consistently more effective at reducing problem behavior. Both procedures proved to be successful in lowering rates of problem behaviors. However, the increased effectiveness of DRA at reducing problem behavior was witnessed across all participants. In addition to this, DRA was also effective in teaching alternate and appropriate vocalizations (LeGay et al., 2010).

This study is significant because, in addition to showing that DRO and DRA are both effective, it demonstrated that they could be effective with non-developmentally delayed children. The authors note that this is important because only 8-10% of the literature on DRO and DRA include children without developmental delays (LeGay et al., 2010).

Differential Reinforcement of Incompatible Behaviors

The last differential reinforcement procedure to be covered is DRI. DRI is a procedure in which one target problem behavior is put on extinction while another behavior is reinforced. The behavior to be reinforced is not any behavior as seen in DRO, nor it is necessarily an appropriate replacement behavior, as seen in DRA. The behavior to be reinforced is one that is incompatible with the problem behavior. The behavior selected to be reinforced must physically prevent the client from engaging in the problem behavior (Cooper et al. 2007). A recent example of the successful use of DRI is the article by Wheatley, West, Charlton, Sanders, Smith, and Taylor (2009). This study successfully used DRI to lower problem behaviors in approximately 200 first grade students. The study took place in the lunchroom of the elementary school the participants attended. The study used a multiple baseline design across three behaviors. The three target problem behaviors were littering, running and inappropriate sitting. Running was defined as having both feet off the floor at the same time and inappropriate sitting was defined as sitting in a position so that both back pockets were not touching the seat. The incompatible behaviors to be reinforced were walking instead of running, putting trash in the proper bin instead of littering and sitting properly instead of inappropriately. While these behaviors may make it appear that this was actually a DRA procedure, a functional analysis was never completed. Therefor, the behaviors are not necessarily alternative behaviors that serve the same function. However, they are incompatible with their matching problem behavior. Reinforcement for the incompatible behaviors came in the form of praise notes. These notes were given to students when one of the incompatible behaviors was witness and then the student put the note in a jar. At the end of the day praise notes were drawn from a jar and the winning student received a prize. In this respect, the notes acted as immediate social reinforcement and also a possible tangible reinforcement. The results of this intervention were a 96% decrease in litter, 65% decrease in inappropriate sitting, and 75% decrease in running.

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While this study provided an example of DRI being successfully implemented, there was one large problem. Due to the number of students participating in this study, it is very unlikely that observers actually recorded every instance of running or inappropriate sitting. This leaves that study open to criticisms that there could be bias in reporting these acts. The exception to this is littering. The littering behavior was judge by the number of pieces of litter following the observation period. This method of data collection was based on a physical artifact left behind by the behavior and is much less likely to be influenced by any reporting bias. Overall, this study was an excellent example of the application of the DRI procedure with a large group of participants.

Summary and Conclusions

Differential reinforcement has a long history of use and is well known in the field of applied behavior analysis. Research showing differential reinforcement to be an effective treatment is ample. For each procedure there are positive and negative aspects. Studies, such as Roane et al. (2007) have successfully mitigated some problems related to specific differential reinforcement procedures. Each procedure also varies in effects and ease of implementation. For example, DRO may be less difficult to implement than DRA but DRA also has the added benefit of teaching a new appropriate behavior. Lastly, DRI has been shown to be effective with large groups of participants and may be an appropriate procedure for use when a DRO or DRA procedure is not viable due to large numbers of participants. In the future, it would be beneficial to see a replication on reinforcement schedule thinning with DRA. A replication should also be conducted assessing the use of DRI with large groups of participants using video recording, so that a truly accurate measure of behaviors can be done.

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