DEGRADING REINFORCEMENT QUALITY FOR TARGET BEHAVIOR DURING DIFFERENTIAL REINFORCEMENT WITHOUT EXTINCTION

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Differential reinforcement of alternative behavior (DRA) interventions that do not use extinction for target behavior offer a class of socially acceptable interventions that are feasible for decreasing target behavior and increasing alternative behavior. Past studies have investigated the influence of combinations of reinforcer dimension (i.e., quality, magnitude, immediacy) manipulations for the alternative response to favor alternative responding. An under-investigated area is reinforcer dimension manipulations for target behavior. If reinforcer parameter manipulations can be made to favor the alternative response that promotes allocation in this direction, reinforcer parameter manipulations can also be made that degrade reinforcement for the target response that may promote response allocation toward the alternative response. If effective, this unique approach may have clinical implications when reinforcement is concurrently available for multiple response options (e.g., DRA without extinction).We investigated if progressively degrading the quality of reinforcement for the target response resulted in decreased allocation toward this response option while simultaneously producing increased allocation toward the alternative response, even when the parameter for the alternative response remained unchanged or when it was associated with higher levels of effort in a translational paradigm. Results indicated that two of five participants demonstrated sensitivity to quality degradation such that an indifference point for quality was identified, and three participants demonstrated frequent switching such that indifference to quality was unclear.

Keywords: differential reinforcement of alternative behavior; extinction; translational

Differential reinforcement of alternative behavior (DRA) is a common intervention used to decrease problem behavior and increase appropriate behavior. DRA interventions have historically involved the use of two procedures: reinforcement of an alternative behavior and extinction of problem behavior (Vollmer et al., 2020; Vollmer & Iwata, 1992). With extinction, the alternative behavior produces access to the functional reinforcer while problem behavior no longer produces access to the reinforcer. These types of DRA arrangements have a documented history of successfully treating problem behavior (Ghaemmaghami et al., 2020)

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Extinction is often a critical component of such interventions making it a necessary procedure for optimal outcomes (Fisher et al., 1993; Hagopian et al., 1998). Although extinction may be required for some, it may also result in potentially deleterious side effects that have been shown to directly impact the success or acceptability of interventions (Lerman et al., 1999). One such side effect is extinction bursts which involve a temporary increase in the frequency and magnitude of potentially explicitly dangerous problem behavior which may decrease social and ecological validity (see Fisher et al., 2023 for discussion). Further, when extinction is prescribed, but not implemented with fidelity, the occasion for the relapse of problem behavior increases substantially (Briggs et al., 2018; Mitteer et al., 2022).

Taken together, clinicians may wish to prescribe interventions that do not require the use of extinction for problem behavior. These interventions, often termed DRA without extinction (cf. Vollmer et al., 2020), involve minimizing reinforcement for problem behavior and maximizing reinforcement for alternative behavior (e.g., Carter, 2013; Lalli, et al., 1999;

Slocum & Vollmer, 2015). In a traditional arrangement of a DRA without extinction, interventions provide reinforcement for problem behavior and alternative behavior using a concurrent operant paradigm (Fisher & Mazur, 1997). For example, if problem behavior occurs, it may result in access to a 30-s break, and when alternative behavior occurs, it may result in a 60-s break. Traditionally, DRA without extinction has been demonstrated to be effective when it involves manipulating the reinforcement dimensions (i.e., quality, magnitude, immediacy) to favor alternative behavior. Previous research has either isolated a single reinforcer dimension (e.g., magnitude [Athens & Vollmer, 2010; Briggs et al., 2019]); or a combination of reinforcer dimensions (e.g., magnitude and quality [Athens & Vollmer, 2010; Briggs et al., 2019; MacNaul & Neely, 2018]). Examples of these manipulations have arranged relatively denser schedules of reinforcement (i.e., reinforcement rate manipulation; Kelley et al., 2002), increased duration of access to the reinforcer (i.e., reinforcement magnitude manipulation; Hoch et al., 2002), shorter immediacy of reinforcement (i.e., delay to reinforcement manipulation; Horner & Day, 1991), higher quality of reinforcement (i.e., quality of reinforcement manipulation; Adelinis et al., 2001), or some combination of each of these for the alternative response (Athens & Vollmer, 2010; Briggs et al., 2019; Piazza et al., 1997) when the participant engages in the alternative response rather than problem behavior. At the current juncture, research does not definitively indicate which manipulations results in the most effective reduction of problem behavior. Rather it appears that these manipulations may be specific to the individual and based on their individual sensitivity to reinforcer parameters (Brown et al., 2021; Kunnavatana et al., 2018; Neef et al., 2001).

Regardless of the exact reinforcement parameters programmed, DRA without extinction interventions produce successful outcomes in decreasing problem behavior. Although many examples exist of reinforcer dimension manipulations, most studies share a common methodology in which researchers have arranged more optimal reinforcer parameters for the alternative response and less optimal reinforcer parameters for problem behavior (e.g., Athens & Vollmer, 2010). For example, Adelinis et al. (2001) investigated the effects of DRA without extinction on rates of compliance and functional communication for a 12-year-old boy diagnosed with autism. Following a preference assessment, Adelinis et al. used the participant's highest quality reinforcer to reinforce appropriate behavior (e.g., compliance with demands, functional communication) and delivered his second highest quality reinforcer when problem behavior occurred. Results suggested that this DRA without extinction arrangement was effective for decreasing problem behavior and increasing compliance and communication. Other studies have used similar procedures in which higher-preferred positive reinforcers were used to reinforce alternative behavior and lesser-preferred positive reinforcers were delivered on the occurrence of problem behavior (e.g., Carter, 2013; Lalli et al., 1999; Slocum & Vollmer, 2015).

Collectively these studies have shown that quality of reinforcement is a critical dimension for consideration when arranging DRA without extinction interventions. A feature that all these studies share is that the alternative behavior produced the highest-quality reinforcer nominated via preference assessment and problem behavior produced either the second-highest or some other less-ranked quality of reinforcer. Another feature is that when problem behavior fails to decrease, researchers manipulated the parameters of reinforcement for the alternative response such that more favorable parameters developed across time (e.g., Athens & Vollmer, 2010; Briggs et al., 2019). For example, Briggs et al. (2019) evaluated the effects of several different reinforcer manipulations during a DRA without extinction procedure. Briggs et al. manipulated either magnitude and quality for alternative responding in isolation initially which was successful for 2 out of 4 participants. However, Briggs et al. found that the combination of quality and magnitude produced optimal conditions for decreasing problem behavior and increasing compliance for 3 out of 4 participants when progressing to reinforcement-schedule thinning and maintained for several weeks.

Thus, one empirically supported arrangement for these interventions is to manipulate the quality of the reinforcer for the alternative response. Interestingly, these studies produced response allocation to the alternative response by directly manipulating the reinforcer dimension for that response; however, conceptually speaking, this effect could also be produced by degrading the reinforcer dimension for the target response because problem behavior is functionally related to alternative behavior. In this manner, rather than increasing favorable conditions for the alternative response, one could arrange a degradation of conditions for the problem behavior. A potential benefit of this approach is that the participant may learn novel response-reinforcer relations such that they may be less likely to engage in problem behavior as they experience a degradation of reinforcer parameters for problem behavior. That is, individuals (a) will directly experience that the target response produces a consequence of relatively lower quality/magnitude, (b) will have experienced that the alternative response produces a consequence of relatively higher quality/magnitude, and (c) will likely choose to allocate responding exclusively to the alternative response despite the target response continuing to produce the functional reinforcer and never having experienced extinction (similar to Justin and Kenneth's responding in Athens & Vollmer, 2010). Reductions in contacting extinction is beneficial because it potentially prevents or reduces the risk of extinction-induced phenomena from being evoked.

To our knowledge, no study has proposed a method for evaluating the effects of degradation of reinforcer dimensions for problem behavior. A potential first step is to begin with degrading the quality of reinforcement for problem behavior. The quality parameter has been shown to be a particularly powerful variable in terms of sensitivity to reinforcement. Previous studies investigating DRA without extinction interventions have had to make manipulations of the quality parameter to make meaningful decreases in problem behavior (e.g., Athens & Vollmer, 2010; Briggs et al., 2019; Kunnavatana et al., 2018).

Given the novelty of this type of research, translational investigations are well-suited to explore this line of questioning. Past studies have used a translational approach to investigate DRA without extinction interventions for testing participant preferences and sensitivities to various reinforcer manipulations (e.g., Brown et al., 2021). Further, translational research offers the benefit of illuminating important findings while exerting precise control prior to exposing clinical populations to interventions that may be underdeveloped.

Therefore, in this study, we sought to answer the following questions using a translational experimental arrangement. We first sought to develop a procedure of a within-stimulus preference assessment for identifying a preference hierarchy across varying qualities of a reinforcer. Next, we investigated whether this hierarchy could be used in a quality tracking assessment to confirm sensitivity to the quality of reinforcement when we arranged the participant's highest and lowest quality reinforcer for an arbitrary button press like the procedures used in Brown et al. (2021). Finally, we used this information to investigate whether we could decrease target responding, a simulation of problem behavior, by degrading the quality of the reinforcer for the target response across the experiment. We subsequently investigated whether the participant would re-allocate towards alternative responding even when they were required to complete a progressive ratio schedule to gain access to their highest quality reinforcer.

METHOD

Participants, Setting, and Materials

We recruited five undergraduate students to participate in the study using an online research participation program. Given this novel procedure, we recruited five participants to ensure data would yield patterns of responding. Adil was a 31-year-old, Hispanic male, Sophie was a 21-year-old, White female, Mila was 29-year-old, Black female, Kat was 20-year-old, Black female, Deja was an 18-year-old, Black female. Participants either majored in Psychology (Adil, Sophie, Mila, Kat) or Accounting (Deja). Participants earned research credits required for an Introductory Psychology course for participating in the study. The experiment was completed in one research session which lasted approximately one hour.

All sessions took place in a 2.57 M by 3.42 M room located in the psychology department at a university located in the southeastern part of the United States. Each room contained a 59.5 in. by 30 in. table, three chairs, and a one-way observation mirror. Session materials included (a) two computerized tablets with an assortment of icons indicating web applications (hereby, apps) used as reinforcers, (b) one purple and one green BIGmack ™ button for engaging in target and alternative responses, (c) worksheets with two-digit by two-digit multiplication mathematical problems, and (d) two laptop computers for data collection.

Response Measurement

The dependent variable was the frequency of target and alternative responses per trial. We defined target and alternative responses as depressing the top of a button with any portion of the participant's hand such that the button fully depressed. We recorded the frequency of each response using a spreadsheet on a laptop computer and data collection software, BDataPro (Bullock et al., 2017). We collected the number of correct reinforcer deliveries which we defined as the experimenter delivering the correct tablet that was prescribed for either a target or alternative response and the experimental phase. We measured the duration of reinforcement intervals and simultaneously measured the duration of item engagement during each reinforcement interval. We defined item engagement as the participant interacting with the tablet by having eye-gaze oriented towards the screen or touching or swiping the tablet screen.

Interobserver Agreement and Procedural Fidelity

We calculated interobserver agreement (IOA) for 100% of sessions across 80% (4/5) participants. We collected IOA by having a second experimenter independently, but simultaneously, record target and alternative responses in each trial. IOA was calculated by exact agreement per trial for a stringent analysis of observer agreement. We calculated agreement by summing the number of trials in which both experimenters scored an occurrence or non-occurrence of target and alternative behavior per trial. We divided this sum by the number of total trials and multiplied by 100 to produce a percentage of agreement. We obtained the following agreement coefficients: (M[trials]= 99%; range, 99%–100%).

We collected procedural fidelity on all sessions across experimental phases for one participant. We collected data on the experimenter's fidelity in delivering the correct type of reinforcer for either target and alternative responses in the within-stimulus quality degradation and progressive ratio phase. We did this by observing video recordings of sessions and scoring the number of correct trials which we defined as the experimenter delivering the prescribed reinforcer relevant for the type of response and experimental phase. We obtained a percentage of procedural fidelity by summing the number of correct trials and dividing this sum by the number of total trials and multiplied by 100 to obtain a coefficient. We obtained 100% for the number of correctly implemented trials.

Pre-Experimental Procedures

We obtained informed consent from each participant prior to the beginning of experimental sessions. We began by allowing the participant to have access to one tablet for approximately 2 min. The tablet contained 20 commonly used apps that spanned categories¬ of social media (e.g., Instagram™), e-commerce (e.g., Amazon™) games (e.g., Candy Crush™), and a search engine (e.g., Google™). The tablets were internet capable for which the participant could use. Please see Supporting Information for a full list of apps.

The experimenter instructed the participant to interact with the available apps on the tablet. The purpose of this procedure was to provide a pre-exposure for participants to allow them to determine which apps were available. Following this brief interval, the experimenter asked the participant to rank their top five most preferred apps (1- highest preferred, 5-lowest preferred) on a paper which displayed images of each app available on the tablet. The experimenter used this ranking to determine which apps to make available for the preference assessment. For example, we used apps ranked first and second in the folder with the top two highest preferred apps in the paired stimulus preference assessment (PSPA).

Paired-Stimulus Preference Assessment

Following the pre-exposure and after the participant ranked the apps, the experimenter programmed each tablet such that only specific apps were available on either tablet in each trial. Specifically, the experimenter created folders on the tablet which contained the selected apps (e.g., top two preferred apps) to program for the preference assessment. We used these preferences to create varying stimulus conditions of each tablet to use for the preference

Name of Condition	Tablet Features
Quality 5 (Q5)	Top 5 most preferred apps with internet
Quality 4 (Q4)	First and second ranked preferred apps with internet
Quality 3 (Q3)	Fourth and fifth ranked preferred apps with internet
Quality 2 (Q2)	No apps with internet
Quality 1 (Q1)	Tablet displaying no apps without internet

Table 1. Quality Ranking Designations

assessment. Please see Table 1 for these arrangements.

We conducted a paired-stimulus preference assessment using the same procedures as Fisher et al. (1992), with the exception that the experimenter described the availability of the apps for each tablet on each trial. For example, the experimenter stated: "On this tablet (i.e., Tablet 1), you can have access to your top five most preferred apps, and on this tablet (i.e., Tablet 2), you can have access to your top two most preferred apps. Both tablets have internet. Select one." Other than the programmed stimulus conditions, the tablets were identical. Data were collected on the number of selections that each participant made towards a specific app arrangement. Then we created a hierarchy from these selections. We nominated these such that the most selected stimulus condition indicated the highest-quality arrangement of a tablet for that participant. Given that there were five varying stimulus conditions included in the PSPA, we nominated the highest quality arrangement as Quality 5 (Q5). We continued this nomination such that the stimulus conditions were arranged as Quality 4 (Q4), Quality 3 (Q3), Quality 2 (Q2), and Quality 1 (Q1).

Sensitivity to Quality Tracking Assessment

Following identification of an individual's hierarchy for quality of the reinforcer, we implemented an assessment to demonstrate that participants would allocate responding towards the highest-quality reinforcer (i.e., Q5). The first purpose of this assessment was to demonstrate a participant's sensitivity to the quality parameter of reinforcement. The second purpose was to demonstrate that participants would re-allocate responding (i.e., switch) towards different buttons in accordance with the button associated with the highest quality reinforcer. This would demonstrate that the participant is making button selections (i.e., tracking) towards the quality of the reinforcer rather than selecting a button due to other stimulus properties (e.g., color, side placement). We placed two BIGmack ™ buttons spaced approximately 6 in. apart and approximately 8 in. directly in front of the participant. We counterbalanced which button was associated with the highest quality reinforcer first across participants.

Q5 vs Q1. During Phase 1, a press to one button produced the Q5-tablet and a press to the second button produced the Q1-tablet. At the start of the tracking assessment, the experimenter instructed the participant to press one of the buttons. To allow for contingencies to shape behavior, the experimenter did not describe which button resulted in either Q5 or Q1. When the participant selected a button, the experimenter delivered the tablet with the prescribed quality stimulus conditions and allowed access to this tablet for 30 s. After the 30-s interval had elapsed, the experimenter asked for the participant to return the tablet and make another selection. This phase was terminated after participant either (a) allocated at least three consecutive responses, or (b) five of nine responses towards the button associated with Q5.

Q5 vs Q1 (Reversal). The procedures in Phase 2 were exactly the same in Phase 1 with the exception that immediately meeting criteria for responding in Phase 1, the experimenter switched the reinforcer associated with the buttons. For example, the button that previously produced Q5 now produced Q1. The experimenter did not reveal this to the participant by making any statements about the switch. The purpose of this was to determine if the participant would track the button associated with Q5 without influence from the experimenter. The experimenter continued this phase until the participant allocated towards the button associated with Q5 using the same criteria in Phase 1. If a participant met these criteria within the research appointment, we determined that the participant demonstrated sensitivity to the quality of reinforcement.

Experimental Procedures

We used a simultaneous treatments design (Kazdin & Hartmann, 1978) which is common in concurrent operant research to evaluate choice allocation. We used this design to make conclusions about sensitivity to the quality of reinforcement when we degraded the quality of the reinforcer for target behavior across phases while simultaneously, and progressively, increasing the work requirements for the alternative behavior.

Forced-Choice Trials

Following the tracking assessment, we conducted two forced-choice trials prior to the start of the within-stimulus quality and progressive ratio assessment. The purpose of the forced-choice trials was to ensure that each button was associated with equitable reinforcer qualities (i.e., both buttons associated with Q5) prior to the start of the experimental phase given the participants recent history in the tracking assessment. In the first trial, the experimenter pointed to a button and stated: "Press that button." Contingent on the participant pressing the button, the experimenter delivered the Q5-tablet for 30 s. After the elapse of 30 s and on the second trial, the experimenter pointed to the other button and stated: "Press that button." The experimenter delivered the Q5-tablet for 30 s.

Within-Stimulus Quality Sensitivity and Progressive Ratio Assessment

Following the forced-choice trials, we began the within-stimulus quality sensitivity and progressive ratio assessment. The purpose of this was to determine sensitivity to the degradation of the quality of the reinforcer. If participants were sensitive to the degradation of quality of a reinforcer, they may be likely to switch to alternative responding to complete a higher response requirement to obtain access to Q5. As such, across phases, we followed a stepwise pattern in which we were either (a) changing the quality of reinforcement or (b) increasing the fixed-ratio (FR) requirement.

Across all trials, when a participant engaged in a response, the experimenter delivered the reinforcer appropriate for that response for 30 s. The target response initially began with access to Q5 and was degraded across the experiment while the alternative response always resulted in Q5. Trials continued until either (a) an hour research appointment had elapsed, (b) a participant progressed to the lowest quality reinforcer (i.e., Q1) for three consecutive sessions, or (c) a participant progressed to and completed the highest work requirement (i.e., FR5) for three consecutive sessions. For all participants, the experimental phase ended because the hour research appointment had elapsed per institutional review board requirement.

Quality Degradation. If a participant allocated towards a target response, we systematically degraded the quality of the reinforcer. We did so by initially allowing access to the highest quality reinforcer. After three consecutive selections to the target response, the experimenter delivered the second highest preferred reinforcer (i.e., Q4-tablet) such that as allocation towards target responding occurred, it resulted in a progressive degradation of the quality of the reinforcer.

Progressive Ratio. If a participant allocated towards the alternative response, we systematically increased the progressive ratio requirement. We did so by initially allowing immediate access to the highest quality reinforcer with no FR requirement. After three consecutive selections to the alternative response, the experimenter asked the participant to complete a two-digit by two-digit mathematical problem (i.e., FR1). Following completion of this requirement, the experimenter allowed access to the Q5-tablet. The FR requirement was increased after three consecutive selections towards an alternative response such that a participant was then asked to complete an FR2. To increase the likelihood that the participant would progress through experimental phases and to decrease the overall delay to the reinforcer, the experimenter did not require accuracy in the FR requirement for access to the reinforcer.

RESULTS

Results from the rankings of apps prior to the PSPA can be found in Supplemental Information. We identified a hierarchy for quality of reinforcement for each participant in the PSPA. All participants, except Deja, selected the tablet with the highest number of available apps and internet most often, and all participants, except Kat, selected the tablet with no apps and internet least often. Two participants (Adil, Sophie) preferred the tablet

Participant	Least Selected	Moderately Selected			Most Selected
Adil	Q1	Q2	Q3	Q4	Q5
Sophie	Q1	Q2	Q3	Q4	Q5
Mila	Q1	Q2	Q4	Q3	Q5
Kat	Q2	Q1	Q3	Q4	Q5
Deja	Q5	Q1	Q3	Q4	Q2

Table 2. Participant Quality Hierarchy Selections for Paired-Stimulus Preference Assessment

associated with a sequential descending order of available apps such that the tablet with the highest number of preferred apps was most often selected, the tablet with a moderate number of preferred apps was moderately selected, and the tablet with no apps and internet was least selected. Mila's hierarchy differed slightly in that she selected the tablet with her two least preferred apps more often than a tablet with her two highest preferred apps. Similarly, Kat selected a tablet without apps and internet more often than she selected a tablet without apps but had internet. Deja's PSPA revealed the most disparate selections from the other participants in that she selected the tablet with her two highest preferred apps and internet the most often, and the tablet with the most apps and internet was her second to least most selected reinforcer. Overall, these results suggest that within-stimulus quality manipulations impact choice-making behavior and reveal varying preferences for qualities of reinforcement. Please see Table 2 for each participant's quality hierarchy.

Participants demonstrated sensitivity to quality within an average of 13.4 trials (range, 11–16). Figure 1 displays the tracking assessment for all participants. Across all panels, the y-axis denotes the selection responses with a range of 0–1 with the number of trials displayed on the x-axis. The phase-change line indicates when the

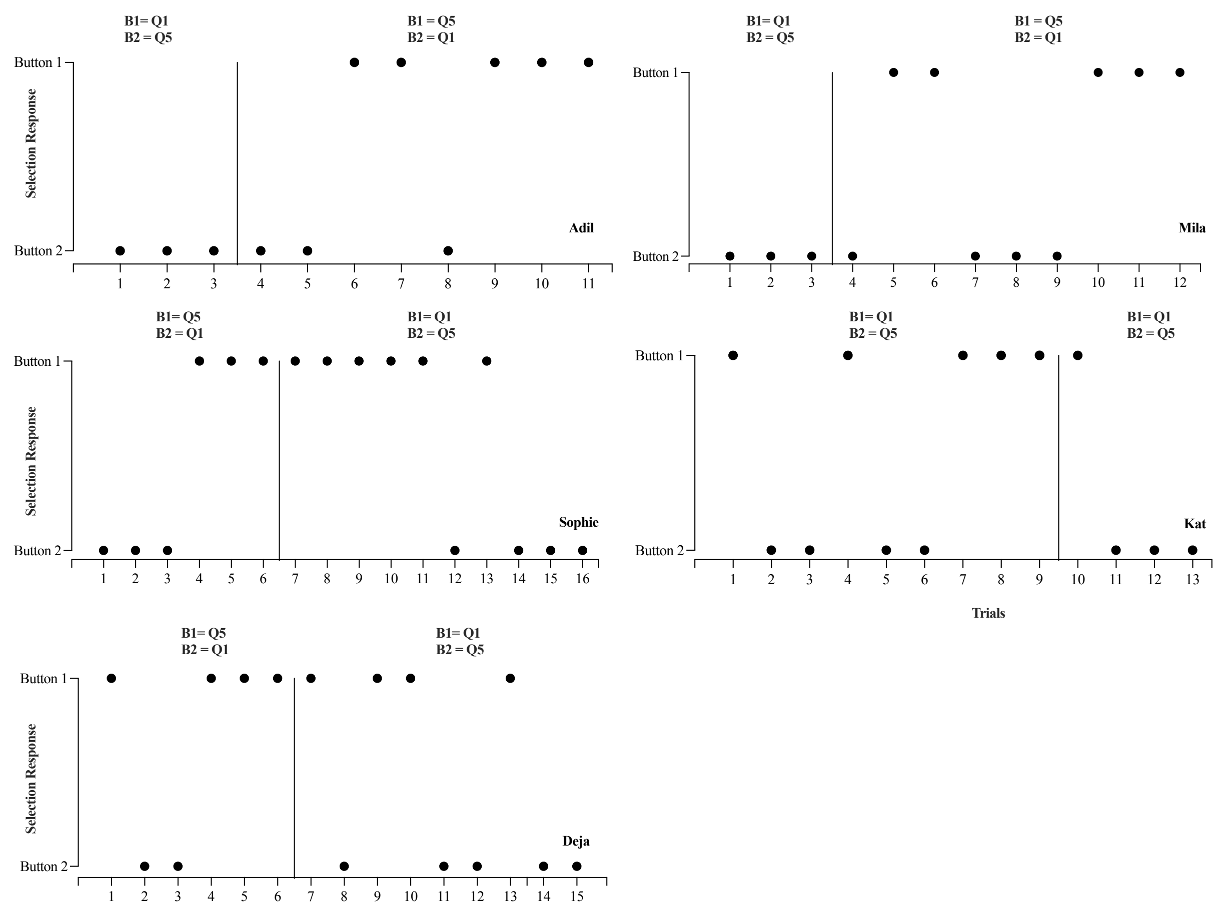

Figure 1. Tracking Assessments Across Participants. *Note:* B1= Button 1, B2= Button 2. Q1= Highest quality reinforcer indicated from preference assessment. Q5= Lowest quality reinforcer indicated from preference assessment. Phase change lines indicate switch in the reinforcer associated with response button.

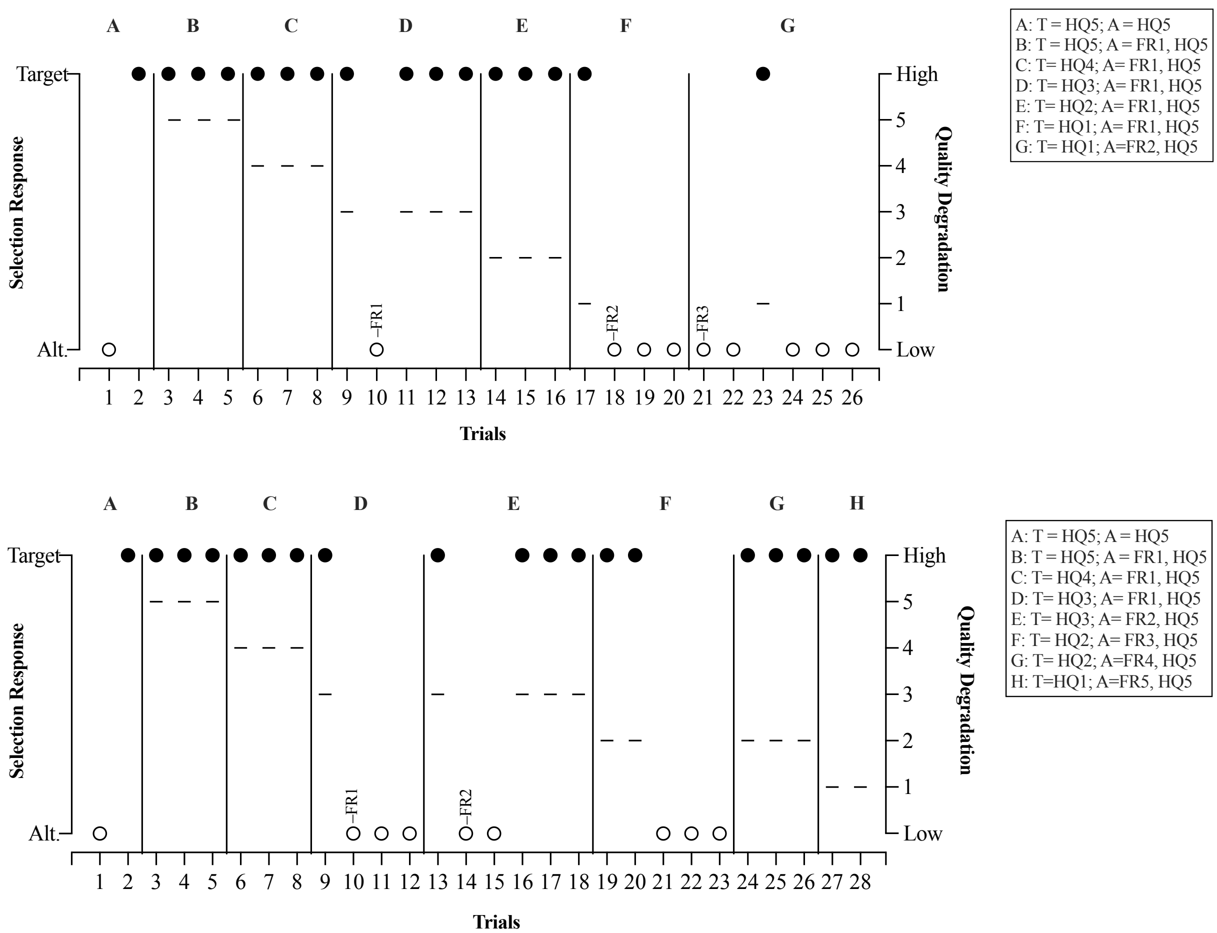

Figure 2. Adil's (top panel) and Sophie's (bottom panel) Within-Stimulus Quality Degradation and Progressive Ratio Assessment. *Note:* HQ5 = Top 5 most preferred apps with internet; HQ4 = First and second ranked preferred apps with internet, HQ3 = Fourth and fifth ranked preferred apps with internet; HQ2 = No apps with internet; HQ1 = Tablet displaying no apps without internet; Alt.= Alternative response; FR= Fixed-ratio.

experimenter switched the reinforcers associated with each button. Adil (top, left panel) displayed allocation towards Q5 for the first three consecutive sessions in Phase 1 and engaged in five trials prior to exclusive allocation to Q5 in Phase 2. Similarly, Mila (top, right panel) immediately allocated towards Q5 for three consecutive sessions in Phase 1 and engaged in six trials prior to exclusive allocation towards Q5 in Phase 2. Sophie (middle, left panel) began her assessment by allocating towards Q1 before making the switch to consecutive allocation towards Q5 in Phase 1. In Phase 2, Sophie maintained responding towards the same button although it produced Q1 for five trials before switching. After two more trials, Sophie engaged in consecutive allocation towards Q5 in Phase 2. Kat (middle, right panel) engaged in several trials of switching before exclusive allocation towards Q5 in Phase 1. When the experimenter progressed to Phase 2, Kat switched towards exclusive allocation towards Q5 after one trial. Deja (bottom, left panel) had three trials before exclusive allocation towards Q5 in Phase 1. Different than all previous participants, Deja did not have consecutive allocation towards Q5 in Phase 2. Instead, she engaged in nine trials in which five were allocated towards Q5. Thus, Deja displayed a different pattern of sensitivity to quality than the other four participants. Item engagement for each reinforcement interval per trial for Adil, Sophie, Mila, and Kat is reported in Supporting Information.

Responding for the forced-choice trials and the within-stimulus quality degradation and progressive ratio assessment for each participant can be found in Figures 2 and 3. Across both figures, the right *y*-axis displays either target or alternative responding and the left *y*-axis displays horizontal hash marks that are consistent with the level of quality available for target responding in that phase. For clarity, we provided phase lines when either a degradation occurred or a fixed-ratio increased depending on when the participant allocated towards a button for at least three consecutive responses. Figure legends for each participant can be found on the right which denotes the current phase for each participant and the specific quality parameters and work requirement in place for each participant during that phase.

To aid with interpretation, we identified two main patterns of responding across participants. Pattern 1 responding (Adil, Kat) involves allocation towards the target response as the quality degrades over the trials. At a specific degradation point (i.e., Q1), the participant switched responding and began to exclusively allocate towards the alternative response revealing an indifference point to the quality of the reinforcer. Pattern 2 responding (Mila, Sophie, Deja) is defined as the participant switching between the target and alternative responding such that no indifference point to the quality parameter clearly emerged. All participants engaged in a similar pattern of responding during the forced-choice trials such that they allocated and switched responding following the instructions of the experimenter.

The top panel in Figure 2 displays Adil's responding during the forced-choice trials and the within-stimulus quality degradation and progressive ratio assessment. Except for one trial, Adil exclusively allocated selection towards the target response. Thus, Adil progressed through the quality degradations for the target response until the final degradation step (Pattern 1). After experiencing this degradation, Adil switched responding to exclusively allocate, except for one trial, towards the alternative response. At the completion of the experiment, Adil completed an FR-3 requirement to gain access to the Q5-tablet.

The bottom panel in Figure 2 displays Sophie's responding during the forced-choice trials and the within-stimulus quality degradation and progressive ratio assessment. Sophie's pattern of responding is consistent with Pattern 2 in that she switched responding throughout the experiment. Initially, Sophie allocated towards the target response; however, she switched to alternative responding upon experiencing Q3. Sophie maintained allocation towards the alternative response to gain access to Q5 until she was required to complete an FR-2 requirement. She continued allocation towards the target response until she reached Q2 for which she switched back to the alternative response. Upon completion of the FR-2 requirement, Sophie switched back to target responding until she reached the terminal degradation of Q1. Overall, Sophie engaged in switching across the experiment and did not reveal a clear sensitivity to the quality degradation.

Similar to Sophie, Mila engaged in a high amount of switching between target and alterative responding throughout the within-stimulus quality degradation and progressive ratio assessment which is displayed in the top panel of Figure 3. After initially allocating towards the alternative response and completing the FR-1 requirement, Mila allocated towards the target response until she experienced the Q3. Mila then engaged in switching between target and alternative responding for 10 trials before allocating towards the target response. She continued this allocation towards the target response until she reached Q1 in which she switched back to the alternative response. Thus, Mila's pattern of behavior is most consistent with Pattern 2 responding.

The middle panel of Figure 3 displays Kat's responding for the forced-choice trials and the within-stimulus quality degradation and progressive ratio assessment. Kat displayed a pattern of responding similar to Adil (i.e., Pattern 1) such that she allocated towards the target response until she experienced the final degradation of the tablet (i.e., Q1). Upon the switch, with the exception for two trials, Kat exclusively allocated towards the alternative response and completed an FR-3 requirement.

Deja's responding for the forced-choice trials and the within-stimulus quality degradation and progressive ratio assessment are displayed in the bottom panel in Figure 3. Deja engaged in a pattern of responding like Mila and Sophie in that she switched back and forth between target and alternative (i.e., Patten 2 responding). However, Deja slightly differed in that after switching between target and alternative responding initially, she began to exclusively allocate towards target responding. She continued to allocate towards target responding even as the quality of the reinforcer degraded across the experiment. Deja continued to allocate towards responding as the quality of reinforcer degraded to Q1.

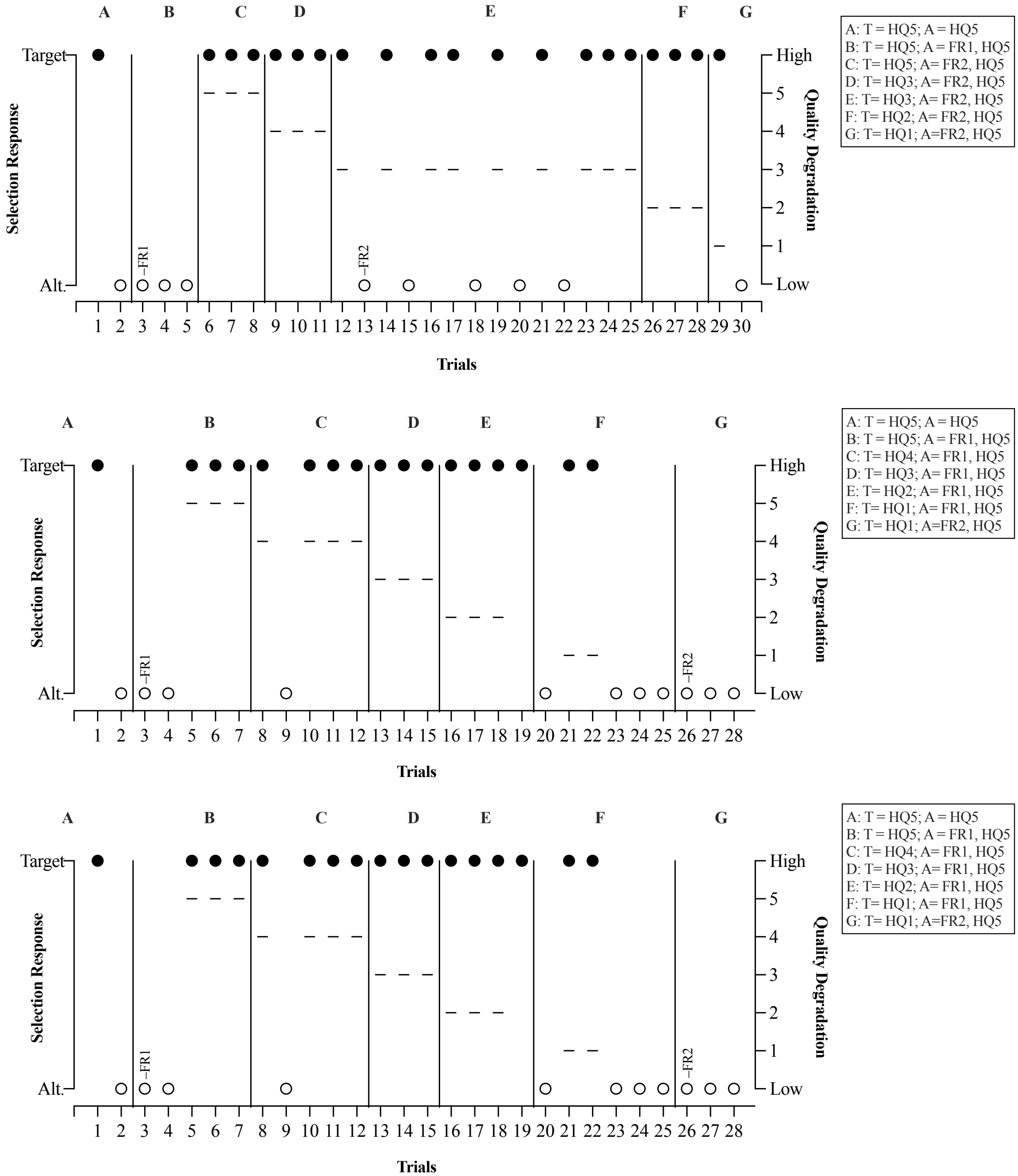

Figure 3. Mila's (top panel), Kat's (middle panel), and Deja's (bottom panel) Within-Stimulus Quality Degradation and Progressive Ratio Assessment. *Note:* HQ5 = Top 5 most preferred apps with internet; HQ4 = First and second ranked preferred apps with internet, HQ3 = Fourth and fifth ranked preferred apps with internet; HQ2 = No apps with internet; HQ1 = Tablet displaying no apps without internet; Alt.= Alternative response; FR= Fixed-ratio.

DISCUSSION

We conducted a novel translational investigation in which we progressively degraded the quality parameter of a tangible reinforcer by decreasing the number of preferred apps available to the participant on their tablet when they selected the target response rather than the alternative response in a concurrent operant arrangement. We observed that 40% (2 out of 5) of participants revealed a clear sensitivity to the degradation of the quality of the reinforcer for which we could identify a specific indifference (i.e., switch) point, and 60% (3 out of 5) of participants did not reveal a clear sensitivity to quality.

Overall, we observed two specific patterns of behavior. The first pattern (i.e., Pattern 1) of behavior (observed with Adil, Kat) was that individuals continued to allocate selections toward the target response until they reached the lowest programmed level of quality for the target response. That is, even when the target response resulted in a reinforcer that was degraded in quality relative to that available for the alternative response, they continued to allocate their selections towards this response. This suggests that even at non-preferred levels of quality, the tablet continued to function as a reinforcer and maintained responding. However, these participants eventually demonstrated a sensitivity to the programmed quality degradations such that when the target response resulted in the lowest-quality stimulus, participants chose to allocate their responding to the response option that required completion of a small work requirement that produced access to the highest-quality reinforcer. This suggests an inverse functional relation to the quality of the reinforcer, such that as the quality of the reinforcer for the target is degraded, the participant is likely to switch to the alternative response.

The second pattern of behavior (observed with Sophie, Mila, & Deja) was that the participant continued to engage in switching behavior throughout the systematic quality degradation of the reinforcer for the target response. That is, there was no identifiable functional relation between the degradation of the quality of the target response and the switch to the alternative response. Instead, these participants continued to switch indiscriminately between the target and alternative responses. Thus, for these participants, it is not clear whether they were relatively insensitive to the quality degradation of the reinforcer for the target response, sensitive to the response effort requirement for the alternative response, reactive to both, or not at all.

We based our manipulations of quality degradation by making inferences about relative quality based on the most and least selected stimulus arrangements in the PSPA. This method has been used in previous research to inform a hierarchy of quality (e.g., Brown et al. 2021; Kunnavantana et al. 2018). This provided individual arrangements of differing qualities of reinforcement amongst participants which may have impacted the speed in which an individual switched to the alternative response. For example, Deja's most selected arrangement (i.e., HQ5) was an iPad with no apps and internet whereas many participant's HQ5 involved an iPad with top five preferred apps. In the first experimental phase, Deja emitted one target response and subsequently switched to the alternative response. Although alternative responding did not maintain initially, this early switch to the alternative response may have been a function of exposure to a potentially low-preferred and low-quality stimulus arrangement. This experience may have impacted results differently for participants who initially experienced a perceived higher quality manipulation. It is possible that latency to switching to an alternative response may occur differentially as a function of exposure to a standardized quality degradation compared to a quality degradation based on selection responses from the PSPA. This might be an area of future research in which the quality degradations are compared between a standardized degradation and an informed degradation from their preference assessments.

This study is novel in two specific ways. First, we conducted a within-stimulus quality preference assessment. Previous studies using a DRA without extinction paradigm have identified the quality of reinforcement based on the hierarchy informed by a PSPA in which a number of different tangible reinforcers were available (e.g., Briggs et al., 2019; Brown et al., 2021). To our knowledge, no study has used a formal assessment approach to identify differential sensitivities to varying parameters of reinforcement within a single stimulus. This may be important because high-tech tangible items such as computerized tablets have been shown to displace other tangible stimuli in preference assessments (Hoffmann et al., 2023). Thus, understanding that this preference is largely due to the number of and differential quality of the various apps available at any given time has important implications for practice. For example, suppose a child's tablet at home differs in various program settings (e.g., use of internet, paid ads, app availability) from the one that is used at school. This variability could directly influence the overall perceived quality of the reinforcement and may produce detrimental effects on interventions. Our data indicate that the varying number of stimulus arrangements (e.g., 5 highest preferred apps vs. 2 lowest preferred apps) directly impacted preference for the tablet, which may influence its efficacy as a reinforcer when used as a consequence during skill acquisition programming. Thus, it may be imperative to understand the within-stimulus quality variations of a reinforcer like a tablet. Future research should evaluate the extent to which this may be the case for clinical populations and the interactions between the number of and types of apps available that may indicate the overall quality of a reinforcer.

The second novel contribution of this study was to determine whether an analog for problem behavior and the alternative response could be influenced in desirable ways without relying on traditional methods that require the use of extinction for problem behavior or improving the quality of reinforcement for the alternative response. Our procedures mark a stark departure from typical arrangements of reinforcer parameters such that we initially allowed for equal parameters of reinforcement for the alternative and target response, then made empirically derived degradations in the quality of the reinforcer for the target response. By doing so, we demonstrated that this approach produced exclusive response allocation towards alternative responding without using extinction for target responding for some participants (i.e., Adil, Kat).

Future research should investigate how the brevity of the study may have impacted the overall rates of responding. That is, it is possible that longer histories with a low-quality reinforcer may have promoted switching to the alternative response. Another important question to clarify would be at what point during the progressive-ratio schedule would participants switch back to target responding. Future studies should consider progressively larger increases in the response requirement to determine sensitivity points to work requirements for the alternative response. In this manner, it would allow experimenters to determine relative breakpoints for both the quality of the target response and the work requirement for the alternative response. This level of analysis could help inform the point at which the work-to-reinforcement ratio is imbalanced, and further reinforcer dimension manipulations are needed to improve the quality or magnitude of the reinforcement obtained for the alternative response or degrade the quality or magnitude of the reinforcement obtained for the target response to maintain desirable levels of responding (Briggs et al., 2023)

Given that improving the quality dimension of the reinforcer for the alternative response is often necessary to influence response allocation away from the problem behavior and toward the alternative response during DRA without extinction, it is reasonable to surmise that degrading the quality dimension of the reinforcer for problem behavior could also produce a similar outcome. This approach is worth exploring because it may offer clinicians an additional (or alternative) strategy when problem behavior fails to decrease during DRA without extinction. Further, it may be that this strategy produces the desired outcome more effectively or efficiently as a stand-alone procedure or when combined with improving the quality of reinforcement for the alternative response. In addition, the very nature of this approach may reduce the bias towards problem behavior during DRA without extinction interventions, which is a common pattern observed in these clinical cases when only the quality of reinforcement is manipulated for the alternative response. However, future investigation of this type of quality manipulation for problem behavior and its influence on responding during DRA without extinction is required before definitive conclusions about its efficacy and recommendations for its use in practice can be made.

This procedure may offer a potential avenue for application in applied settings when the use of extinction is not feasible, undesirable, or safe to implement. In these cases, the degradation of the quality parameter for target responding may be a potential option. This procedure can be conceptualized as a differential reinforcement procedure in which we minimize reinforcement for target responding (Vollmer et al., 2020). Rather than applying extinction at the onset of the treatment, we minimize reinforcement for target responding over time. In this manner, the potential negative side effects associated with extinction may be avoided (e.g., response bursting, relapse). Additionally, when the participant engages in target responding, degrading the quality of the reinforcer over time may offer potential benefits by actually teaching the participant that the response-reinforcer relation for target responding is relatively less than that available for the alternative response without relying on extinction and risking the occurrence of extinction-induced phenomena. Learning this relation in this manner may promote discriminative control that encourages the participant to ultimately choose the alternative response over the target behavior rather than learning this relation abruptly when the target behavior is placed on extinction.

This procedure may also be beneficial in that it may potentially address a common complication experienced during DRA without extinction interventions that involve an individual's potential bias toward problem behavior because of a long-standing history of reinforcement. In this arrangement, problem behavior can occur and produce reinforcement; however, as the quality of the reinforcer degrades, this may produce conditions that promote switching towards the alternative response option such that the individual will contact this relatively high-quality reinforcer, thus decreasing the likelihood that bias will continue to occur. However, at this juncture, this benefit is solely speculative and future research should consider exploring if this is indeed the case. Specifically, following a DRA intervention in which the participant continues to reveal a bias toward problem behavior even when the alternative response produces more favorable outcomes, researchers may consider incorporating the degradation of the quality procedure so as to promote switching and increase the likelihood the individual contacts the relatively higher quality reinforcement associated with the alternative response. At this time, it is unknown if this procedure could prevent or remediate this potential bias, especially for cases involving long learning histories for engaging in problem behavior; therefore, future research is needed to determine this procedures impact on biased responding.

Although this procedure offers a potential option when arranging a concurrent operant intervention for treating problem behavior, some additional considerations are warranted. First, it is necessary that a participant first demonstrates sensitivity to the quality of reinforcement. Although the quality of reinforcement is a commonly manipulated variable, varying levels of sensitivity to reinforcement quality could directly impact the success of the intervention. For example, Deja's tracking assessment indicated lower sensitivity to the quality of reinforcement, and we observed a high amount of switching in the within-stimulus quality degradation and progressive ratio assessment. Thus, researchers should be tentative when manipulating reinforcer quality because it may not be a variable all participants are sensitive to any additional approaches may be necessary.

Although this study offers some promising avenues for applied interventions and future research, this study is not without limitations. The first is that participants were college students whose responding may have been influenced by the experimenter rather than the programmed contingencies. Thus, participants may have selected tablet choices because they were following a potential rule rather than allowing for the contingencies to shape their behavior. Although we did not collect information from participants about rule following, we noted anecdotal comments made by participants. For example, Kat commented about disliking math at the introduction of math problems. Perhaps this is why she discontinued responding towards the alternative response following two trials. It is also possible that experiences with aversive consequences such as math problems influenced responding. Future research should replicate these procedures with populations that are likely to experience DRA without extinction interventions and not as influenced by rules (e.g., children with problem behavior).

The second limitation is that we did not require participants to have accurate completion of math problems. We observed 50% accuracy of completed math problems across all participants. Our results may have differed had we required accuracy for completion such that participants may have been less likely to allocate towards the alternative response.

A third limitation is that we did not conduct a reversal during the within-stimulus quality degradation and progressive ratio. This reversal to a previously higher quality consequence would have further confirmed sensitivity to the quality of reinforcement. Future research may consider conducting a reversal within this assessment, as well as making progressively higher response requirement increases consistent with applied research. Finally, we arbitrarily selected the quality manipulations to use in the PSPA. It is possible that we would have obtained different results based on the quality arrangements. For example, the degradation from having a tablet that has no apps to a tablet that has no apps without the internet may be an imperceptible quality manipulation for some participants. Thus, a necessary next step would be to identify the best possible arrangements for programming quality of high-tech reinforcers.

Notwithstanding these limitations, we found that some participants were sensitive to the degradation of the quality of the reinforcer, suggesting a tentative possibility that degradation of the quality parameter for target responding may hold a promising approach for the treatment of problem behavior when extinction is not a possibility. This study may offer an initial step in a new understanding of manipulating the dimensions of reinforcement for both alternative and target responding. Gaining a deeper understanding of how manipulating dimensions of reinforcement and parameters within a dimension for both the target and alternative response may offer a more complete approach to designing effective DRA interventions that do not rely on the use of an extinction component.

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