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Stimulus Fading and Response Elaboration in Differential Reinforcement for Alternative Behavior

Kevin J. Schlichenmeyer,

University of Massachusetts Medical School - Shriver Center and Applied Behavioral Learning Services

William V. Dube, and

University of Massachusetts Medical School - Shriver Center

Mariela Vargas-Irwin

Applied Behavioral Learning Services

Abstract

A hallmark of applied behavior analysis is the development of function-based interventions for problem behavior. A widely recommended function-based intervention is differential reinforcement of alternative behavior (DRA), in which reinforcement is contingent upon socially acceptable alternatives to problem behavior (e.g., teaching communication skills). Typically, DRA is introduced under rich schedules of reinforcement. Although effective for initiating behavior change, rich schedules are often impractical in the natural setting. In this study, we evaluated the extent to which a stimulus fading program could be employed to elaborate alternative behavior (mands) in two individuals diagnosed with an Autism Spectrum Disorder. For both participants, problem behavior was reduced substantially upon implementation of the DRA procedure. Further, problem behavior rates remained low and mand rates decreased to more practical levels as the DRA behavioral requirements increased during the fading program. The fading approach demonstrated in this paper may be a useful component of intervention packages for clinicians.

Keywords

fading; stimulus control transfer; DRA; functional communication training; self-injury; screaming; autism

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Effective function-based interventions for problem behavior begin with a functional analysis to identify reinforcers that maintain the behavior (Iwata, Dorsey, Slifer, Bauman, & Richman, 1994). In many cases, the intervention involves providing the maintaining reinforcer for alternative behavior while reinforcement is withheld for problem behavior, a procedure that has been termed differential reinforcement of alternative behavior (DRA). In a common and straightforward approach known as functional communication training (Carr & Durand, 1985) relevant reinforcers are provided for appropriate requests. For example, if

the problem behavior is maintained by escape from demands, the individual may be taught to ask for a break; if the behavior is maintained by attention from others, the individual may be taught to ask for attention. Typically, DRA interventions are introduced with relatively rich schedules of reinforcement and little or no delay to reinforcement for the alternative response. Following the introduction of a successful intervention, the reinforcement schedule is often adjusted so that the alternative response can be reinforced on a more practical schedule. Depending on the situation, the reinforcer-thinning strategy may involve the introduction of multiple schedules in which signaled reinforcement conditions alternate with signaled extinction conditions during which the DRA is not available (Fisher, Kuhn, & Thompson, 1998; Hagopian, Kuhn, Long, & Rush, 2005; Hagopian, Toole, Long, Bowman, & Liewing, 2004; Jarmolowicz, DeLeon, & Kuhn, 2009). The multiple-schedule approach has been shown to be more effective than simply introducing a delay to reinforcement (Hanley, Iwata, & Thompson, 2001; Sidener, Shabani, Carr, & Roland, 2006). However, for some individuals the introduction of extinction may produce undesirable side effects such as aggression, agitated or emotional behavior, resurgence of previously reinforced behavior, and so forth (Lattal, St. Peter, & Escobar, 2013; Lerman & Iwata, 1996). One possible approach to this problem is to reduce the rate of reinforcement by gradually increasing the DRA response requirements, thereby extending the duration of time during which the individual is engaged in alternative behavior prior to each reinforcer.

Stimulus fading is one technique that could be used to increase response requirements. Catania (2013) describes *fading* as a generic term for gradual changes in the stimulus properties that define a discriminated operant. (For other approaches to the classification of techniques for gradual and progressive stimulus changes see Lancioni & Smeets, 1986; McIlvane & Dube, 1992). With some existing discriminated response as a starting point, stimulus fading can be used to bring that response under new forms of stimulus control and/or change the response topography to accommodate gradual changes in the stimuli. Examples of this class of procedures include gradual changes in stimulus intensity or amplitude (e.g., to “fade out” a prompt), in the shape or form of a controlling stimulus (e.g., morphing), or in the temporal relations between the onsets of prompts and target stimuli (e.g., progressive delayed cue procedures). A noteworthy feature of this approach is that it requires neither physical prompting nor verbal instruction.

Stoddard and Gerovac (1981) provides an early example of stimulus fading (called “stimulus shaping” in that paper) to elaborate response topographies. Participants were children and adults with severe to profound levels of intellectual disability. They were alone during experimental sessions within a teaching laboratory in which they could earn poker-chip tokens for discrimination tasks and exchange those tokens for reinforcers such as snack foods (Stoddard, 1982). An opportunity to exchange a token was signaled by a flashing red light on a slot in the wall, and the participant exchanged a token by inserting it into the slot. This was a relatively complex motor task for many participants that required picking up the token from the desktop, orienting it to match the slot, inserting it, and pushing it all the way into the slot. At the initial program step, the experimenters (behind the wall with the slot) extended about 1/3 of a token from the flashing slot. Participants had previously learned to respond to a flashing red light, and the initial response requirement was merely to touch the

token, which was then withdrawn and a reinforcer dispensed. Over successive program steps, the token remained extended until the participant pushed it into the slot. Next, successively greater portions of a token (attached to a string held by the experimenter) were extended from the slot to shape orienting the token. Then the token on the string was extended successively greater distances from the slot until it reached the tabletop and finally lay flat on the table, to shape picking it up (see the paper for further details). Stoddard and Gerovac found this procedure to be successful for all participants with specific procedural modifications.

Three characteristics of stimulus fading programs designed to produce a transfer of stimulus control seem especially relevant to the elaboration of DRA responses. First, the process should begin with responses that are already in the repertoire and easily evoked. Second, the procedures should verify observing of all relevant stimuli. This can be accomplished by requiring some differential response to each stimulus, for example, picking up an object and placing it within a container verifies observation of both the object and container. Third, new stimuli and responses should be introduced in the presence of existing discriminative stimuli. "One can conceptualize successful stimulus shaping as the presentation of stimulus aspects that already control responding, based on [previous] learning ... along with one or more new stimulus properties that will hopefully gain control." (Stoddard & Gerovac, 1981, pp. 291-292).

This paper will present two clinical examples to illustrate the application of stimulus fading to the elaboration of DRA response requirements. The procedures incorporated the three characteristics of stimulus fading programs just described.

Method

Participants and Settings

Two participants were referred by clinical teams because of severe problem behavior. Both participants had been diagnosed with an Autism Spectrum Disorder. Jack was an 11-year-old boy who could follow multi-step instructions without prompting and spoke full sentences. Edward was a 12-year-old boy who could follow basic one-step instructions. His primary form of communication was a DynaVox speech generating device.

Jack's sessions were conducted in a family room located in the basement of his home where he typically received home-based applied behavior analysis therapy. Therapists 1 and 2 were his mother and father, who conducted sessions under the supervision of a consulting Board Certified Behavior Analyst®. Edward's sessions were conducted at his school in a small room (1.5 m × 3 m) furnished with a table and two chairs. These sessions were conducted by two therapists from his school. Sessions were recorded with a digital video camera.

Responses and Measurement

Jack exhibited a wide range of problem behavior including property destruction, aggression, and screaming. Because screaming was reported to precede property destruction and aggression, it was targeted for intervention. *Screaming* was defined as any vocalization exhibited above conversational level. Edward was referred to the study for head-directed

self-injurious behavior (SIB). *SIB* was defined as forcible contact between Edward's hand (open handed slap or closed fist punch) and any portion of his head, as well as any instance of forcible contact between his head and any hard surface.

Trained observers used a desktop computer to code videos of therapy sessions. Continuous data recording systems were used and data were summarized as percentage of session duration or responses per minute. For Jack, a percentage measure was used because screaming occurred at varying durations. Percentage screaming was calculated as the number of seconds with screaming divided by the total number of seconds in a session, multiplied by 100%. For Edward, a response per minute measure was used because SIB had discrete start and end points. SIB rate was calculated as the number of instances of self-injury divided by total number of minutes in a session.

Functional Analysis

Jack's functional analysis began with an open-ended functional assessment interview (Hanley, 2012) with his mother. The interview included both antecedent questions (e.g., "Does problem behavior occur when you interrupt activities?") and consequence questions (e.g., "What do you do to help calm him down?"). The interview results suggested that problem behavior was evoked when preferred activities, such as playing with his handheld computer (iPod Touch), were interrupted with a demand (e.g., tooth brushing). Two separate single-function tests (see Iwata & Dozier, 2008) were conducted to test these possible reinforcement contingencies (i.e., negative reinforcement: escape from demands; positive reinforcement: access to preferred activities). The test for negative reinforcement was conducted first. In the Demand condition, Jack's mother presented continuous demands (i.e., brush teeth, put on shoes, and throw paper away) and delivered praise following compliance. Contingent on screaming, escape from demands was provided for 30 s. In the No Interaction (control) condition, Jack's mother sat in the same room but did not interact with him; no demands were presented and any problem behavior was ignored. The test for positive reinforcement contingencies was conducted next. The Tangible Test condition began with 2 min access to his computer. After 2 min, Jack's mother stated, "It's all done," and removed the computer. Contingent on screaming, Jack was provided with 30 s of additional computer time. During the Tangible Control condition, Jack's mother stated, "You can play as much as you want," Jack's computer play was not interrupted, and any problem behavior was ignored.

For Edward, functional analysis conditions resembled those described in Iwata et al. (1994). Prior to the start of the Alone condition, the therapist told Edward, "You need to stay in here for a little while. I need to leave and will be back in 10 minutes," and Edward was alone in the room with no leisure items available. During the Attention condition, the therapist told Edward, "I need to do some work and will not be available for 10 minutes," and then sat in a chair reading a magazine. Contingent on each occurrence of SIB, the therapist provided brief social attention and non-punitive physical contact (e.g., "Don't do that, you'll hurt yourself" while placing a hand on Edward's shoulder). During the Play condition, preferred leisure items including a bubble-blowing toy and "Wiggles" video (previously identified as preferred on a preference assessment) were continuously available. At the start of the

session, the therapist stated, "You can have Wiggles and bubbles." The therapist sat in a chair and did not prompt the subject to play with the bubbles or watch the Wiggles video, or present other requests or demands. SIB produced no differential consequences. If Edward initiated play or communication, the therapist interacted with him. If Edward did not initiate interaction, the therapist attended to him every 30 s by providing 5-10 s of praise (e.g., "It's nice hanging out with you!" or "Cool video!"). Demand and Tangible conditions were conducted as described in Jack's analysis (Demand and Tangible Test); in the tangible condition the Wiggles and bubbles play items were delivered for 30 s following SIB.

Figure 1 shows the results of the functional analysis for Jack and Edward. For Jack, screaming was observed during the initial Demand condition, but decreased to zero levels with further sessions. Upon implementation of the Tangible condition, elevated levels of problem behavior were observed relative to the control condition, suggesting Jack's screaming was maintained by positive reinforcement in the form of computer delivery. For Edward, SIB was consistently observed in the Tangible test condition and not observed during the other conditions. Edward's SIB was determined to be maintained by positive reinforcement, delivery of the play items.

Treatment Assessment

Baseline—At the beginning of each session, the participant and therapist were seated in chairs at a table or standing near it. Contingencies during baseline sessions were the same as those for the Tangible conditions of the functional analyses. Jack's sessions were 5 min in duration; Edward's sessions were 10 min.

Intervention Step 1: DRA—For both participants, a DRA intervention was implemented. Treatment effects were evaluated via a multiple-baseline-across-therapists design. The intervention consisted of teaching the participant to emit a mand (request) for the play item. For Jack, the teaching procedure was developed during one session following the baseline phase. For both participants, pre-session prompts were given before the first two Step-1 treatment sessions. Specifically, the therapist provided instructions ("When I say it's all done you can ask for more time") and then role played with the participants by gesturing to take away the preferred activities and prompting the mand. Jack's mand was to ask, "Can I have that please?" or "Can I have more time please?" Edward's mand was pressing either the "Bubbles" or "Wiggles" buttons (labeled with pictures) on the DynaVox device. When the mand was emitted, participants were provided 30 s of access to the preferred activities. For the remaining treatment sessions, the participant was provided 2 min of access to preferred activities prior to the session. After 2 min, the therapists stated, "It's all done." If the participant did not stop, the therapist terminated the activity by removing the play items. If participants emitted the mand, the play items were returned to the participant for 30 s. If problem behavior occurred during the mand (e.g., Jack screaming while manding), preferred activities were withheld until the behavior had ceased for 5 s and an appropriate mand was emitted. There were no other programmed consequences for Edward's SIB; it never escalated during DRA sessions to the point at which interruption was necessary to prevent tissue damage.

Intervention Steps 2, 3, and 4: Stimulus Fading Program

When low levels of problem behavior were observed for at least two sessions with the DRA contingencies (Step 1), a stimulus fading program was implemented. The contingencies for fading sessions were identical to the DRA conditions described previously but with additional response requirements.

Step 2 added instructions to throw away a piece of paper into a trash bin located within 1 foot of the participant. When a mand occurred, the therapist said, “Sure you can have more time, first I need you to throw this away.” Upon completing the task, the participants were given 30 s with the play items.

Step 3 consisted of moving the trash bin beyond arm’s reach but within sight, approximately 4 m from the table, such that the participant had to walk over to it to throw the paper away. For Jack, the trash bin was placed near the bottom of the stairs leading from the basement to the first floor of his house. For Edward, the bin was placed in the hallway just outside a partially closed door.

Step 4 consisted of moving the trash bin further away and out of the direct line of sight. For Jack this was in the room at the top of the basement stairs, and for Edward it was further down the hallway.

Generalization Probe

After the intervention program was completed with Therapist 1, it was initiated by Therapist 2. When Step 1 had been established with Therapist 2, the final step of the fading program (Step 4) was probed; that is, participants were not exposed to Steps 2 and 3 prior to the Step 4 probe. The probe was conducted to determine whether a second exposure to the fading procedure was necessary with the second therapist. If elevated levels of problem behavior were observed, Therapist 2 initiated intervention Step 2 in the following session. If elevated levels of problem behavior were not observed, the therapist continued with Step 4.

Interobserver Agreement

Functional analysis—Inter-observer agreement was calculated by dividing the sessions into consecutive 10-s intervals. Percentage agreement for screaming (Jack) was calculated by dividing the smaller duration of responding by the larger duration of responding in each interval, averaging these fractions across the session, and multiplying by 100%. Inter-observer agreement for SIB (Edward) was calculated by dividing the smaller number of responses by the larger number of responses in each interval, averaging these fractions across the session, and multiplying by 100%. Agreement was scored for a minimum of 33% of sessions of each condition for both participants. Mean total agreement for screaming (Jack) was 99.9% (range, 99.6 - 100%), and mean total agreement for SIB (Edward) was 99.1% (range, 97.1 - 100%).

Treatment assessment—A second independent observer recorded responding for a minimum of 33% of sessions as described in functional analysis sessions, above. Mean total agreement for screaming (Jack) was 97.6% (range, 81.6 - 100%), and mean total agreement

for SIB (Edward) was 99.7% (range, 96.8 - 100%). Mean total agreement for the mand was 96.1% (range 90.5% to 100%) for Jack, and mean total agreement for the mand was 92.2% (range, 83.9 - 100%) for Edward.

Results

Figure 2 shows the results of the treatment assessment, fading program, and generalization probe for Jack. During baseline with Therapist 1, high stable levels of screaming were observed and mand responses were not observed. When the DRA was implemented, screaming was nearly eliminated and mands substantially increased. In Step 2, screaming remained low and mands occurred at levels consistent with those observed in Step 1. Upon implementation of Step 3, screaming continued to occur at low rates and, as expected, mand rate decreased as the response requirement increased. During Step 4, screaming remained low and mand rate again decreased. In a follow-up session one week later, screaming and manding rates were unchanged.

During baseline with Therapist 2, there was a slight increasing trend in Jack's screaming and mand responses occurred at low and inconsistent levels. Upon implementation of the DRA (Step 1), screaming decreased and mands increased, replicating the intervention results with Therapist 1. During the Step-4 generalization probe with Therapist 2, SIB occurred at high rates and manding decreased. Because of this, Steps 2 and 3 were implemented in subsequent sessions. SIB remained low and manding decreased concurrent with the increased response requirement, a trend which continued upon implementation of Step 4. At follow up, one week after the Step-4 session, screaming did not occur and manding was observed to occur at levels similar to the previous session (mand data were not collected in Sessions 8 and 14 due to experimenter error).

Figure 3 shows the treatment assessment results with Edward. During baseline with Therapist 1, SIB occurred at elevated levels. Edward could not mand during baseline conditions because his communication output device was not present. Upon implementation of the DRA with Therapist 1, problem behavior was reduced to zero levels with one exception (Session 9) and mand responses occurred at generally high levels. When Step 2 was introduced, SIB rate remained low and mand response rates decreased by the third session. In Step 3, reductions in SIB were sustained and mand rate continued to decline. In Step 4, the low rates of SIB continued and mand rate was stable.

During baseline with Therapist 2, Edward's SIB rate was initially low, but high variable rates were observed over the last 5 sessions. Upon implementation of the DRA with Therapist 2, decreases in SIB were observed concurrent with high stable levels of mands. During the Step-4 generalization probe in Session 13 and subsequent sessions, SIB remained low and mand response rates generally decreased over subsequent sessions. One exception was Session 14, in which Edward emitted a burst of mands with a series of rapid and repeated button presses that continued even as the play items were presented; this did not occur again.

Discussion

For both participants, contingencies that maintained problem behavior were identified through functional analyses. DRA interventions were effective in establishing socially acceptable alternative behavior (manding) and reducing the rates of problem behavior to very low levels. The stimulus fading program was effective in reducing the frequency of manding by approximately 50% (compare rates for Steps 1 and 4 in Figs. 2 and 3) while maintaining problem behavior at low rates. The Step-4 probe sessions with Therapist 2 showed generalization of the elaborated DRA response across therapists for Edward but not for Jack. These results indicate that a stimulus fading program may be a useful component of intervention packages for some individuals receiving treatment for problem behavior, in particular those for whom the introduction of extinction may be problematic while reinforcement rate for DRA responding is high. By elaborating response requirements via fading, the rate of reinforcement for DRA behavior can be reduced without an extinction contingency for that behavior.

In the introduction, we described three characteristics of fading programs with relevance for the elaboration of DRA responses via transfer of stimulus control: begin with easily evoked responses already in the repertoire, verify observing of relevant stimuli, and introduce new stimuli and responses in the presence of existing discriminative stimuli. Intervention Step 2 exemplified the first characteristic in that the response was easily evoked; the trash bin was immediately at hand, the participant had thrown papers into such bins before, and the response cost (effort) was minimal. This step was also consistent with the second characteristic in that it verified observing both the paper and the trash bin. Step 3 exemplified the third characteristic by introducing the new responses of standing and walking to the trash bin, and for Edward opening a partially closed door, in the presence of existing discriminative stimuli (paper and trash bin) that already controlled DRA behavior. Step 3 also introduced new stimuli, the stairs for Jack and the door and hallway for Edward, in close proximity to the existing discriminative stimulus of the trash bin. In Step 4, the participant could not see the trash bin while seated at the table. Successful transfer from Step 3 to Step 4 illustrated that the stimuli introduced in Step 3 (the stairs for Jack and the door and hallway for Edward) now controlled behavior, including the responses of standing and walking that were also introduced in Step 3. When Jack went to the bottom of the stairs, or Edward walked to the door and opened it, each could now see the trash bin in its new location, and the bin continued to control the behavior of approaching it and throwing away the paper.

One limitation of this study is its relatively brief duration, both in terms of session duration and the overall number of sessions. Session durations of 5-10 min, although not uncommon in treatment assessments, do raise the question of generalizability to activities with longer durations. It would have been informative to evaluate whether session duration could be extended as the inter-mand intervals increased as a result of the elaborated response requirements. A related limitation concerns the overall brief duration of the treatment assessment and follow-up. Jack's treatment assessment was discontinued after a one-week follow-up because the experimenter (KS) was no longer providing applied behavior analysis therapy services to the family. Edward did not receive follow-up sessions because his

clinical treatment team at his school elected to pursue other treatment options. It is thus not clear from the present data whether the elaborated DRA responses could be maintained for weeks or months, although it seems likely that any continuation of this type of treatment would include further elaboration and variation. For example, the individual might be asked to pick up additional items to throw out on the way to the trash bin, or to retrieve other items on the way back to the table where the play items were presented. Continued elaboration and variation seems feasible if the procedures for introducing new stimuli and responses incorporate the fading program characteristics described above.

A second limitation is that there were no formal extinction probes prior to initiation of the fading procedure in Step 2. It is therefore possible that neither Jack nor Edward would have exhibited problem behavior if signaled extinction had been introduced after the DRA response was established in Step 1. Although possible, the stability of problem behavior during baselines, Jack's relapse in the Step-4 probe with Therapist 2, and Edward's unexplained relapse for one session during Step 1 (Fig. 3, Session 9) suggest otherwise. In practice, the DRA response-elaboration approach might be reserved for cases in which the introduction of multiple schedules alternating between DRA and signaled extinction does in fact produce unwanted side effects.

Stimulus fading techniques can be applied to a wide variety of behavior. For example, in a residential setting (like Jack's) one could design a program that parallels the one described above to elaborate a request for play items to include putting away clean laundry. Such a program might begin with placing a dresser drawer next to the child and asking him or her to put away a pair of socks. In subsequent steps, the therapist could gradually move the location of the drawer to an upstairs bedroom and ultimately into the dresser. Further elaboration could increase the number of items to put away and their initial locations. In an academic setting, a similar program could involve putting away academic materials after asking for a break from school work, with gradual increases in the number of items and their storage requirements and locations. For these and other applications of this approach, success may be reasonably predicted by incorporating the three characteristic of stimulus fading programs that encourage transfer: start with existing behavior, verify observing, and introduce new stimuli and responses in a context of secure stimulus control.

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Figure 1.
Functional analysis results for Jack (top) and Edward (bottom).

Figure 2.
Treatment assessment, fading program, and generalization probe results for Jack.
Numbers* indicate Intervention Steps.

Figure 3. Treatment assessment, fading program, and generalization probe results for Edward. Numbers* indicate Intervention Steps.