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Gradually Transitioning to a New Taxonomy: Thinning, Shaping, and Fading

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Abstract

Currently, there is a large body of work in the basic and applied literature about schedule thinning and the underlying concepts associated with these procedures. However, some of the terminology used in this research area (e.g., shaping, fading, and thinning) has been applied inconsistently, suggesting that researchers and practitioners might misunderstand these terms. In this paper, I will discuss the unsystematic use of terminology found in the literature describing schedule thinning procedures, as well as other gradual change procedures, more generally. Additionally, I will propose a new taxonomy of gradual behavior change procedures in the hope of creating a more systematic use of the terminology.

Introduction

Schedule thinning is a term used to describe a variety of techniques for decreasing, or "thinning," an existing schedule of reinforcement by gradually increasing the response ratio or the duration of the time interval (Cooper, Heron, & Heward, 2007). Schedule thinning procedures are pervasive within Applied Behavior Analysis (ABA). In treatment contexts, dense schedules of reinforcement are almost always initially required to demonstrate treatment effects (Hagopian, Boelter, & Jarmolowicz, 2011). However, these dense schedules are very seldom representative of the schedules of reinforcement the individual will contact in the natural environment, and it is these lean, naturalistic schedules that will be required to maintain behavior in the long-term. Therefore, while dense schedules are appropriate for the initial stages of treatment, they are, in almost all cases, inappropriate for maintaining behavior in future, naturalistic settings. Thus, schedule thinning is an essential component to virtually any effective treatment plan.

In our everyday lives, situations that resemble schedule thinning procedures might occur quite frequently. This kind of "naturalistic thinning" might be so gradual that the transition from rich to thin schedules occurs over years, or even across the entire lifespan. For example, when I was younger and just started learning how to brush my teeth, my mom provided attention and praise (i.e., reinforcement) every time I engaged in appropriate tooth brushing. As I aged, my mom checked up on my tooth brushing less and less frequently, and yet I still continued to brush my teeth. Thus, the schedule of reinforcement was successfully thinned. Now, virtually the only time my tooth brushing behavior is reinforced is every six months when I visit the dentist. This is only one example of naturalistic schedule thinning- other examples might include the transition from interacting with high school friends every day, to only interacting with these friends every

few weeks (in college); or the transition from frequent feedback from an instructor in an early graduate course to completing a capstone paper in the final semester.

In ABA treatment, schedule thinning is implemented deliberately, as part of programming for generalization and maintenance, if not built-in explicitly as a behavior change target. For example, when implementing a treatment in which the student completes math problems, the practitioner might start the intervention by providing reinforcement on a continuous schedule (i.e., providing reinforcement contingent upon every math problem answered correctly; fixed ratio [FR 1]). In subsequent sessions, while the student is frequently answering questions correctly, the practitioner might "thin" the schedule of reinforcement by increasing the parameter of the ratio requirement to two responses (i.e., FR 2), thereby only providing reinforcement following every two correct responses. If this schedule thinning process continues, the practitioner might continue to thin the schedule until the terminal treatment goal (e.g., an entire worksheet, FR 10) is reached. Thus, the rationale for implementing this gradual thinning procedure is to decrease rate of reinforcement while simultaneously maintaining treatment gains (in the present example, correct responding).

Given the prevalence and importance of schedule thinning techniques, it is perhaps unsurprising that a variety of thinning procedures have some support in the behavior-analytic literature. However, there are also substantial limitations of this literature. In Hagopian, Boelter, and Jarmolowicz's (2011) review of schedule thinning research in the context of functional communication training (FCT), the authors noted that there is extremely limited literature evaluating the pacing of schedule thinning procedures (i.e., how fast to thin), which is an essential component of these techniques. Furthermore, a cursory review of the literature reveals a hodgepodge of terms used to describe these techniques, including but not limited to, fading

(demand, stimulus, and delay), leaning, schedule thinning, rich-to-lean transitions, and dense-to-lean transitions. The extent to which these varying terms describe functionally similar (or identical) procedures has yet to be examined systematically.

The lack of a systematic analysis and categorization of schedule thinning terminology is potentially problematic for a number of reasons. First, lack of consistent terminology could make it difficult for researchers and practitioners to locate relevant research to inform clinical practice. If multiple terms are used for (functionally) identical procedures, this could fragment the literature. For example, researchers might label studies with keywords (e.g., "schedule thinning") while practitioners use different terminology in their searches of the literature (e.g., "fading").

Second, unsystematic application of terms could lead to mislabeling of procedures. For example, Freeman and Piazza (1998) used the term "stimulus fading" to describe a procedure designed to increase food consumption. In their procedure, the initial feeding trials involved presenting a single spoonful of the subject's preferred food items each trial. Then, the quantity of food was increased by 5% every time the subject reached 80% compliance (i.e., food acceptance) for three consecutive meals. Though this procedure involved "fading" of an aversive stimulus (i.e., food), in this case the aversive stimulus consisted of a demand (i.e., "consume the food"). Therefore, increasing the quantity of food consumed might be more accurately described as demand fading, rather than stimulus fading. This example demonstrates the need for a systematic analysis of schedule thinning terminology.

Third, unsystematic use of schedule thinning terms might be a barrier to translation of relevant findings from the basic literature to application. A search of the Journal of the Experimental Analysis of Behavior at the time of the present literature review yielded only nine articles containing the phrase "schedule thinning;" only one of these articles investigated

schedule thinning as an independent variable (Sweeney & Shahan, 2013). Thus, it is reasonable to question whether schedule thinning procedures are based on a firm understanding of the behavioral principles that are "in play" while implementing such procedures. In an unpublished masters' thesis, Kincaid (2013) noted that basic researchers tend to use the term "leaning" to refer to procedures for decreasing reinforcement (i.e., transitioning to a "lean" schedule), whereas this term is seldom used in applied contexts. It is also possible that the basic research literature includes analysis of procedures that are relevant to applications of schedule thinning. Regardless of the explanation, it is evident that clear links between the two literature bases are not yet established.

To address these concerns, in this paper I will discuss schedule thinning and related procedures in the ABA literature, including demand fading, delay fading, multiple schedules, shaping, stimulus fading, and instructional fading. These procedures will be categorized according to the term(s) of the three-term contingency (Skinner, 1969, p. 7) on which they act. Additionally, I will discuss the basic research principles and empirical literature that might underlie, and inform, each "applied" procedure.

Schedule Thinning Procedures and FCT

In their (2011) article, Hagopian and colleagues reviewed schedule thinning procedures in the context of FCT. As FCT is one of the key areas of applications of schedule thinning, I will begin by discussing the procedures presented in this review. Then, I will extend Hagopian et al. by (1) describing the function of these procedures with respect to the three-term contingency, and (2) reviewing the basic research principles underlying these procedures.

Demand Fading

As discussed by Hagopian et al. (2011), “demand fading involves increasing the number of demands that must be completed before the opportunity to emit the alternative response is made available or before the alternative response produces reinforcement.” For example, one of the articles included in Hagopian et al.’s review was an investigation by Lalli, Casey, and Kates (1995) that used demand fading to reduce problem behavior maintained by escape and increase task completion using FCT + extinction (EXT). During the treatment phase, escape from an aversive task was presented when the functional communication response was emitted. During demand fading, the researchers increased the response requirement by increasing the number of communication responses that resulted in break presentation. Experimenters presented subjects with a task to complete. Following completion of the task, escape from the task (i.e., a break) was provided contingent upon the first mand for a break. Future sessions involved higher response requirements (e.g., FR 16; 16 tasks) in order to earn the opportunity to mand for a break from tasks. The results showed that the demand fading procedure was successful in decreasing rates of problem behavior.

Interestingly, Lalli, Casey, and Kates (1995) labeled their demand fading as a “response chaining” procedure. Similarly, in Hagopian et al.’s (2011) review, the authors discussed how demand fading can be synonymous with chained schedules of reinforcement, in which completion of an “initial link” (FR 16 of tasks) produces access to a “terminal link” (reinforcement of mands on an FR 1). Additionally, in the response restriction procedures discussed in the Hagopian et al. review, the chained schedule might consist of a fixed-time component (restriction interval) followed by a terminal link (presentation of the communication device, reinforcement of mands on an FR 1). The use of “chained schedule” in this context refers

to a schedule of reinforcement arrangement in which “two or more basic schedule requirements occur successively, and have a discriminative stimulus correlated with each independent schedule” (Cooper, Heron, & Heward, 2007). This differs from chaining, which is defined as “various methods for linking specific sequences of stimuli and responses to form new performances” (Cooper, Heron, & Heward, 2007). Thus, although chaining and chained schedules/demand fading may be functionally similar, demand fading is commonly used as a treatment for problem behavior maintained by escape from demands (Hagopian et al., 2011), whereas chaining procedures are used for acquisition of skills (e.g., [teaching Olympic powerlifting] Moore & Quintero, 2019).

Table 1 summarizes the procedures discussed in the present review. As seen in the Table, demand fading operates on the response requirement of the reinforcement contingency. Thus, demand fading involves increasing amounts and/or types of responding that result in reinforcer presentation. It is important to note that while demand fading might indirectly act to decrease the overall rate of reinforcement per unit (e.g., session) time, demand fading does not directly impact reinforcement per se, and therefore is an indirect method of thinning a schedule. For example, imagine that an individual is working to earn a 3-min break following the completion of some work. At the beginning, the individual might only be required to complete one worksheet before earning a break. However, as the sessions progress and the work requirement increases (i.e., having to complete more worksheets to earn a break), the individual will not have as many opportunities to earn breaks within that 10-min session because the task will take longer to complete. Thus, though demand fading is discussed as a method of schedule thinning, this method decreases the rate of reinforcement via increasing response requirements, or more precisely, the ratio of responding to reinforcement.

Demand fading might be analogous to a procedure used in the basic literature known as progressive ratio (PR) schedules. A PR schedule requires the organism to emit a steadily increasing number of responses per reinforcer delivery. For example, under a hypothetical PR schedule, after a rat presses the bar once, an edible reinforcer will be presented. As the session goes on, the rat will be required to emit more and more bar presses to result in reinforcer presentation. Progressive ratio schedules can follow a progression of ratios arithmetically (e.g., adding two bar press requirements to each step) or geometrically (e.g., multiplying the total number of bar presses by two for each step). When the organism stops responding for a pre-determined amount of time, this is labeled the "breaking point," and the session typically terminates. In early investigations, basic behavioral researchers were interested in determining the point at which ratio requirement becomes too high and the organism stops responding. Two findings from the PR literature might have implications for applied behavior analysts implementing schedule thinning: satiation and step size.

Hodos and Kalman (1963) conducted a seminal investigation of the effects of step (i.e., increment) size and reinforcer magnitude on PR schedule performance. In applied settings, small step size is typically used with schedule thinning. For example, suppose a practitioner is implementing a treatment in which correct completion of math problems is reinforced with edible items. The demand fading procedure might initially consist of delivering the edible after every correct math problem (i.e., FR 1). Following steady responding, the practitioner will then deliver reinforcement after every other correct math problem (i.e., FR 2). The process of increasing the response requirement by 1 might continue until the successful completion of a full worksheet (e.g., FR 10). Increasing the response requirement by a small amount (e.g., 1 math problem) each time constitutes a small step size.

Interestingly, Hodos and Kalman found that when small step sizes were used under a PR schedule, satiation occurred quickly, and therefore a decline in responding occurred. This suggests that large step sizes can be used to thin the schedule of reinforcement and maintain steady responding. This might be important in applied contexts in which demand fading consists of small increments in the response requirement. Hodos and Kalman's findings suggest that satiation might occur when the schedule is thinned too slowly, and that (perhaps counter-intuitively), increasing the requirement quickly might lead to more effective demand fading. To take the example given above, suppose the client begins to exhibit signs of satiation (e.g., lack of attending to or consumption of the reinforcer, increase in precursors to problem behavior or problem behavior itself, etc.). Hodos and Kalman's findings would suggest that, in this situation, the practitioner should consider a more rapid demand fading procedure. For example, instead of increasing the response requirement by 1 each time (i.e., from 5 to 6 math problems), the practitioner might consider increasing the response requirement by 3 each time (i.e., a step size of 3; from 5 to 8 math problems).

Some practitioners might believe that increasing the response requirement in small steps might allow the client to ultimately reach a leaner schedule, or larger terminal goal (i.e., instead of completing 10 math problems, the individual might complete 20). However, basic research does not appear to support this rationale. The effects of step size on break point were evaluated by Stafford & Branch (1998). Using a PR schedule, the researchers determined the break point of pigeons' key pecking behavior. The researchers evaluated a wide range of step sizes, from PR 1 to PR 240 (e.g., PR 3, PR 15, PR 80, etc.). Similar break points were observed within subjects, regardless of step size. In other words, no matter the step size used to increase the response requirement, the behavior of the organism still broke down, on average, at the same response

requirement. In relation to the example above, if the practitioner used the smaller step size (i.e., from 5 to 6 math problems) or the larger step size (i.e., from 5 to 8 math problems), the learner would still reach the terminal goal (i.e., 10 math problems completed), but in a shorter period of time. Meeting the terminal goal sooner might result in more opportunities to target other behavior goals. Furthermore, Stafford and Branch's findings suggest that if a terminal goal (e.g., 20 math problems) cannot be reached using a large step size, this problem would not be ameliorated by using a small step size. This further supports the idea that practitioners should consider using larger step sizes in practice, to avoid satiation and conduct the thinning process efficiently. At this time, there is not enough research to confirm that the example given above would be successful in an applied setting. This is a hypothesized example and this body of work might benefit from a larger line of research on this topic.

Delay Fading

Hagopian et al. (2011) also discussed the use of delay fading with FCT. Delay fading involves delaying the delivery of a reinforcer following the communication response. This is common in FCT practice because, although it is often necessary that responses are reinforced immediately to gain treatment effects early on in the treatment process, naturalistic reinforcers are often delayed. For example, in the workforce employees are often not paid immediately. Instead, they must wait one or two weeks for a paycheck. However, before making the leap to 1-2 weeks of waiting time, it is important to first gain treatment effects with the learner. Once treatment effects have been observed, a brief delay can be implemented, and the delay can then be extended over time.

Delay fading operates on the immediacy of the reinforcement contingency (see Table 1) by decreasing the immediacy of reinforcement (i.e., increasing the delay to reinforcement

presentation). Decreasing reinforcer immediacy might indirectly result in decreased rate of reinforcement, if the delay results in fewer opportunities to respond. For example, time spent "waiting" for reinforcement takes up session time, resulting in a lower overall reinforcement rate.

Hagopian, Fisher, Sullivan, Acquisto, and LeBlanc (1998) used a delay fading procedure to increase the delay between a request and the delivery of reinforcement for clients who exhibited high levels of tangibly- or attention-maintained self-injurious behavior (SIB), aggression, and/or property disruption. Following the acquisition of a functional communication response, the researchers determined that 14 out of the 21 clients emitted the mand at such high rates that they received continuous reinforcement. To decrease the rate of manding, the researchers implemented a delay fading procedure in which the client was told to wait after emitting the mand. Following a successful waiting period in which no target behavior occurred, the client was given attention or the item they manded for. The delay was slowly increased (i.e., 1 s, 3 s, 5 s, 7 s, etc.) until a final waiting goal of 5 min was reached. The results of this study showed that 90% behavior reduction was reached in about 44% of all cases. However, this behavior reduction only maintained in about half of the applications that used delay fading. The authors suggested that the delay weakened the contingency between the response and the reinforcer and therefore resulted in resurgence of target behavior.

This suggestion is supported by a relatively large body of research into the effects of delays to reinforcement in the basic literature. For example, the importance of reinforcer immediacy was demonstrated by Sizemore and Lattal (1977). In the study, the researchers compared the effects of delayed reinforcement to immediate reinforcement and noncontingent reinforcement (NCR). Delayed reinforcement was implemented via a tandem VI-FT (i.e.,

variable interval-fixed time) schedule. Under the tandem schedule, contingent upon the first response after the interval had elapsed, an FT delay (i.e., clock) began. Following the FT, food was presented. This schedule was compared to a traditional VI schedule without delays to reinforcement, and NCR via a VT schedule. The results showed that the key peck responding decreased when reinforcement was response dependent but delayed, relative to response dependent with no delay. During the VI schedule, responding occurred at high rates but during the tandem VI-FT responding was decreased by about half. This study is just one example of delay weakening the contingency between the response and reinforcement. This finding might be relevant to applied settings because Sizemore and Lattal showed how much responding was decreased even by a short delay (e.g., 1 s). In light of these findings, it is interesting that Hagopian et al. were able to demonstrate successful maintenance of responding under delayed reinforcement with some of the cases presented.

Multiple Schedules

Another line of research discussed in the Hagopian et al. (2011) review was schedule thinning using multiple schedules of reinforcement. A multiple schedule of reinforcement involves two or more basic schedules of reinforcement in an alternating sequence. The change in schedule is always presented with a discriminative stimulus (Cooper, Heron, & Howard, 2007). Within the context of schedule thinning, multiple schedules have been used to decrease reinforcement of an alternative behavior following FCT. The multiple schedule approach can be combined with other methods of schedule thinning, including delay fading (e.g., Kelley et al., 2011) and demand fading (e.g., Lalli et al., 1995).

Hanley, Iwata, and Thompson (2001) were the first to employ a multiple schedule as a means of progressively thinning a schedule of reinforcement for a communication response. The

multiple schedule consisted of two components. One component operated on an FR 1 schedule and produced 10-s access to a preferred edible and the second component involved extinction of the alternative response. When the intervention initially began, the FR 1 component was in place for 45 s while the extinction component was in place for 15 s. A discriminative stimulus was present during each component: a round white card was present during the FR 1 component and a rectangular red card was present during the extinction component. Following two consecutive sessions with low rates of SIB, the duration of the extinction (and occasionally, the FR) schedule component was gradually increased. The initial duration of the schedule components were 45 s and 15 s for the FR and extinction components, respectively. The duration of the components was increased to a final duration of 60 s of FR 1 and 240 s of extinction. Results showed that self-injury occurred at near-zero rates and alternative behavior occurred at moderate and stable rates as the duration of extinction increased. With two other subjects, the authors compared a mixed schedule (i.e., unsignaled changes in schedule) and multiple schedule. Results showed that by using the multiple schedule, researchers successfully thinned the schedule of reinforcement while problem behavior remained low, whereas the mixed schedule resulted in high rates of problem behavior during both the FR and extinction components.

The results of Hanley et al.'s study suggested that multiple schedules are an effective method to thin the schedule of reinforcement for the alternative response. The signaled change in schedule facilitated faster schedule thinning, likely because the cards served as discriminative stimuli for the upcoming condition. Therefore, when extinction was gradually faded in, subjects did not emit the alternative response during extinction components because there was post-reinforcement pausing from the previous (reinforcement) condition. During the mixed schedule condition (without discriminative stimuli), despite identical criteria for schedule thinning,

subjects continued to emit the alternative response during extinction, which led to slower thinning of reinforcement and higher rates of problem behavior.

As seen in Table 1, multiple schedule thinning procedures directly affect the reinforcement term of the three-term contingency. This method directly changes the programmed reinforcement rate because in a given session, increasing the s-delta period decreases the total amount of reinforcement that can be earned. Additionally, under multiple schedule thinning, antecedent discriminative stimuli are altered because there are programmed discriminative stimuli (SD and s-delta) correlated with the change in schedule components. Within the basic literature, multiple schedules are frequently employed as a control technique (Sidman, 1960). Furthermore, multiple schedules are also used as an experimental technique in applied contexts, within multielement designs. There are some discussions about response induction and carryover in multiple schedules (e.g., behavioral contrast), but it is unclear how these findings directly link to multiple schedules as a treatment approach. Currently, models of multiple schedules in the context of schedule thinning have not been investigated. Thus, an analog investigation of multiple schedule thinning in a basic operant experiment might present a helpful, controlled evaluation of schedule thinning effects under multiple schedule procedures.

Other Gradual Change Procedures

Although the techniques discussed in the Hagopian et al. (2011) review are successful methods for schedule thinning, they are not the only methods of gradual behavior change. The following sections will discuss other methods of gradual behavior change procedures conceptually related to schedule thinning, including shaping, stimulus fading, and instructional fading.

Shaping

Researchers have demonstrated how shaping techniques might be used to achieve a terminal goal by reinforcing successive approximations of a behavior. Successive approximations can be prerequisite skills to the terminal behavior or have the same response topography of the terminal behavior (Cooper, Heron, & Heward, 2007). For example, Cameron and Capello (1993) developed a 11-step shaping program to teach an individual with Down syndrome to leap over hurdles in preparation for the Special Olympics. During each step of the shaping procedure, the height of the hurdles was changed or more hurdles were added depending on the subject's success during the previous step until mastery criteria was met. Results of this study showed that the subject was able to obtain the skill of leaping over hurdles and the behavior maintained during a one-month follow-up. The authors also noted that the behavior was obtained during a short period of time (i.e., 4 weeks) and with very few errors emitted by the learner.

Shaping operates on the response requirement of the reinforcement contingency (see Table 1). Shaping requires changes in the topography of a behavior that will result in reinforcement presentation (i.e., the response requirement) to reach a terminal goal. For example, when teaching a non-vocal child to mand for a ball, the practitioner might start the shaping intervention by reinforcing the successive approximation "buh." Once the child has mastered this skill, the practitioner will reinforce a closer approximation (e.g., "ba"). The practitioner will continue changing/increasing the response requirement until the terminal goal "ball" is reached. At the end of the shaping intervention the learner engages in a terminal response that might require more response effort, or a novel topography, or both. The terminal response will typically result in the same magnitude of reinforcement that was previously presented contingent upon the initial successive approximations.

As seen in Table 1, shaping and demand fading both involve increases in the response requirement that might indirectly decrease reinforcement rate, thereby thinning the schedule. Similar to the distinction made earlier in this paper between demand fading and chaining, demand fading is a procedure used more often in the context of treatments designed to decrease problem behavior (e.g., escape from an aversive task), whereas shaping is used to teach new skills. However, these behavior goals might go hand-in-hand, and practitioners might use shaping and demand fading interchangeably. Similar to the example with the ball above, the magnitude and rate of reinforcement remains the same during a shaping procedure while the response requirement is changing (i.e., "buh" to "ba" to "ball"). However, demand fading might serve to decrease reinforcement throughout the intervention by requiring more work to be completed and leaving less session time to gain reinforcement.

The basic research literature describing shaping procedures is relatively robust. For example, Eckerman and colleagues (1980) shaped a pigeon's peck from an original key to an alternative key by varying the step size of key location. During shaping, the key which produced reinforcement (i.e., alternative key) was moved further away from the original key. The step sizes of the key shifts were varied in three ways: 0.5 in., 1.0 in., and 1.5 in. to the left. The researchers found that pecks were able to be shaped to emit the new response under both small and large shifts, but that shaping occurred faster when step sizes were larger. This suggests that behavior can be shaped when step sizes are larger and using larger step sizes might be a time-saving technique. In reference to the example above, instead of teaching the child to say "ball" by adding one sound at a time, the practitioner might consider increasing the response requirement by two or three sounds at a time. Eckerman et al.'s research supports using larger step sizes and might lead to faster attainment of acquisition goals. This might inform applied

practitioners and their treatment techniques and encourage them to use larger step sizes when shaping behavior.

Stimulus Fading

Another method of gradual behavior change is stimulus fading. Stimulus fading involves initially highlighting a physical dimension (e.g., color, size, position) of a stimulus to increase the likelihood of a correct response, then decreasing the magnitude of the highlighted dimension over time (Cooper, Heron, & Heward, 2007). For example, when teaching a child to read, the letters might be presented in a larger font at the beginning of the training. However, when the learner masters the initial phase of training, the font size will be slowly decreased until a normal font size has been reached and the learner is still successful in reading the words.

In a study conducted by Grob, Lerman, Langlinais, and Villante (2018), researchers used behavioral skills training (BST) and stimulus prompts to teach job-related social skills to adults with autism spectrum disorder. After conducting an initial assessment of job-related social skills, the authors identified areas of difficulty for each subject. Using the specific areas of difficulty, the researchers began training the subjects to engage in appropriate social skills using BST and stimulus prompts. Prompts were individualized for each subject (i.e., prompts given, size of font, color of paper, etc.) During a post-training phase, prompts were faded. For example, for one subject, the brightness of a textual prompt was gradually decreased (e.g., from 100% to 50% to 15% brightness), then eventually the prompt was removed all together. For another subject, stimulus fading consisted of decreasing the size of the visual prompt (i.e., reducing the size of the paper and the font), such that the subject could transport the prompt to the job setting. This is one example of fading a stimulus while maintaining appropriate responding.

Stimulus fading operates on the antecedent component of the three-term contingency (see Table 1). Specifically, stimulus fading alters properties of the discriminative stimulus by systematically decreasing the salience of the stimulus (i.e., discriminative stimulus or prompt). Thus, stimulus fading only requires changes in the discriminative stimulus, and not in the response requirement or reinforcement component (i.e., magnitude, immediacy, and rate) of the three-term contingency. Although schedule thinning and stimulus fading both employ gradual transitions to the terminal (i.e., treatment) goal, the aspects of the contingency upon which these procedures operate are fundamentally different. It is possible that the term "stimulus fading" is being over-generalized to other fading procedures, potentially due to the vagueness of the term itself. Within behavior analysis generally, the term "stimulus" could refer to a number of different stimuli (e.g., reinforcing stimuli, demand stimuli, etc.). However, with respect to stimulus fading procedures, "stimulus" is used as shorthand for "discriminative stimulus."

Unlike several of the other techniques discussed in this review, there is a clear and direct link between stimulus fading procedures and the basic research literature. In Terrace's (1963) seminal study, the author found that when a new stimulus (e.g., a newly lit key) is introduced in a pigeon's environment, the pigeon will respond on the stimulus even without the delivery of reinforcement (i.e., emit "errors"). To teach the pigeons not to respond on the novel stimulus, Terrace began discrimination training with a novel key. Instead of introducing the key at 100% illumination, the author slowly faded in the key light (i.e., increased the brightness of the light in small increments). This fading procedure resulted in continued responding on the target key and no responding on the novel key. This study gave way to the procedure known in the applied literature as "errorless learning" (Mueller, Palkovic, & Maynard, 2007).

Instructional Fading

Instructional fading was described by Pace and colleagues as the initial removal, then subsequent gradual reintroduction, of demands to prevent problem behavior (Pace, Iwata, Cowdery, Andree, & McIntyre, 1993). In their study, Pace et al. determined that the SIB of three subjects was maintained by escape from an instruction demand. The researchers used a treatment package consisting of extinction plus instructional fading to decrease SIB and increase compliance with instructions. Following a session with no occurrences of SIB, the instructors began delivering one instruction at a time. Contingent on no SIB, the instructors continued "fading in" instructions. The researchers did not use a systematic method of fading, other than the nonoccurrence of SIB during the previous condition. Results showed that this treatment package was successful in reducing SIB and increasing compliance. In this example, instructional fading is clearly used synonymously with "demand fading," as described above.

Alternately, instructional fading might also refer to stimulus fading. For example, if a student is given a work sheet with instructions at the top, and these instructions serve as a prompt (i.e., instructions on how to complete the worksheet) which will eventually be faded out, instructional fading might actually be implemented as stimulus fading. Thus, instructional fading could be more accurately labeled as demand fading or stimulus fading, depending on the function of the instructions. If instructions are prompts, then the procedure being used is stimulus fading. If the instructions are demands, then the procedure being used is demand fading. This example highlights the importance of categorizing gradual-change procedures based on functional differences in procedure, rather than the names of the procedures. Failure to do so might further lead to misuse of terms and misunderstanding in the literature.

Gradually Transitioning to a New Taxonomy

Applied Behavior Analysis has a robust literature of behavior change techniques that employ gradual transitions. However, this area is challenged by a hodgepodge of terminology with similar terms being used to refer to functionally distinct procedures. The lack of clear connections between the underlying behavioral principles (basic research) and treatment techniques has led to confusion and an overgeneralization of terms. To address this confusion, I propose a new taxonomy of gradual transition techniques in ABA, shown in Figure 1. Under this taxonomy, the terms used to refer to the gradual change procedures discussed in this review are kept the same, however, these procedures are now grouped functionally, based on the changes to the three-term contingency enacted by each procedure. Three categories of gradual-change procedures are proposed: Thinning, Shaping, and Fading.

The first category, Thinning, includes procedures that decrease the total amount of possible reinforcement per unit of time. Thinning procedures are, in a sense, the "truest" form of schedule thinning, because they are the only procedures that directly decrease reinforcement. The procedures in this category include thinning that occurs within the context of a time- or interval-based schedule (FI, FT, etc.), multiple schedules (with SD and s-delta periods of fixed duration), or delay fading (with systematically increasing periods of wait time). Using a time- or interval-based procedure will limit the amount of reinforcement that an individual can receive during a set unit of time, thereby thinning the schedule of reinforcement. The goal of Thinning procedures is to decrease programmed rate of reinforcement while maintaining responding.

Next, Shaping includes procedures that increase the response requirement, either by number of responses (e.g., FR 1, FR 2, etc.; demand fading; instructional fading implemented as demand fading), topography of responses (shaping), or both (shaping and chaining). Increasing

the response requirement might indirectly decrease reinforcement, perhaps because the target response takes more time to emit, or requires much higher response effort and therefore occurs at a lower rate. Thus, Shaping procedures are indirect methods of schedule thinning. The goal of Shaping procedures is to shape up new responding or new patterns (e.g., sustained high rates) of responding.

The final category, Fading, includes procedures that produce changes in the properties (i.e., salience) of the discriminative stimulus (e.g., SD, prompts, instructional fading as stimulus fading), but does not alter the reinforcement contingency. This procedure includes stimulus fading, which requires the SD to be faded out by changing color, shape, size, etc. It is important to note that this category includes procedures that operate on antecedent control only, and the "stimulus" of stimulus fading refers to discriminative stimulus.

This new categorization system is functional because it groups procedures not based on their previous names but by the functional changes in the contingency each procedure operates upon. This should increase the likelihood that researchers and practitioners discuss and evaluate procedures in a conceptually systematic way. Rather than lumping procedures together based on arbitrary qualities such as the topography, or what the procedure "looks like" in practice, we should evaluate whether a procedure is appropriate based on the underlying mechanism(s) of the procedure. In light of my proposed taxonomy, it is perhaps unsurprising that unsystematic use of terminology was at the forefront of literature in this area. For example, the term "fading" was used across all three categories of the proposed taxonomy: Thinning (delay-to-reinforcement fading), Shaping (demand fading), and Fading (discriminative stimulus fading). Furthermore, when considering these procedures in light of their functional, rather than topographical, features, it is clear how distinct these procedures are in research and practice. Delay-to-

reinforcement fading is implemented to teach waiting, whereas demand fading is primarily applied in the treatment of escape-maintained problem behavior. Finally, discriminative stimulus fading manipulates the antecedent component of the contingency to transfer stimulus control to the natural environment. Thus, these procedures operate on three different aspects of the three-term contingency (reinforcement, behavior, and antecedent stimuli, respectively; see Table 1), and probably should not be described using a single term.

I propose this new categorization system with hopes that it ameliorates some of the miscommunication in the literature, or at the least, assists novel practitioners to cope with the numerous terms used to describe gradual change procedures. I am not proposing that the terms currently in use should be abandoned. Terms such as “shaping,” “thinning,” and “fading” have been in use since the inception of ABA, and these terms likely exercise strong stimulus control over researchers, practitioners, and students of behavior analysis. Thus, I propose a taxonomy that will help behavior analysts to continue to use these terms, but more systematically.

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Table 1.

Directly and indirectly affected terms of the three-term contingency

Applied Procedure	**Example Applied Study**	**Directly Affected Dimension**	**Change in Directly Affected Dimension**	**Indirect Effects**	**Related Basic Procedure**	**Example Basic Study**
Demand Fading	Lalli et al. (1995)	Response	Increasing response requirement	Decreasing rate of reinforcement	Progressive-Ratio	Hodos and Kalman (1963)
Delay Fading	Hagopian et al. (1998)	Reinforcement	Decreasing immediacy of reinforcement	Decreasing rate of reinforcement	Contingency vs. Contiguity	Sizemore and Lattal (1977)
Multiple Schedules	Hanley et al. (2001)	Reinforcement	Decreasing rate of reinforcement	Changing antecedents (via changing SD S-delta durations)	N/A	N/A
Stimulus Fading	Grob et al. (2018)	Antecedent (Discriminative Stimulus)	Decreasing highlighted stimulus dimension	Everything else kept consistent	Stimulus Fading	Terrace (1963)
Shaping	Cameron and Capello (1993)	Response	Increasing response requirement	Reinforcement rate kept consistent	Shaping	Eckerman et al. (1980)

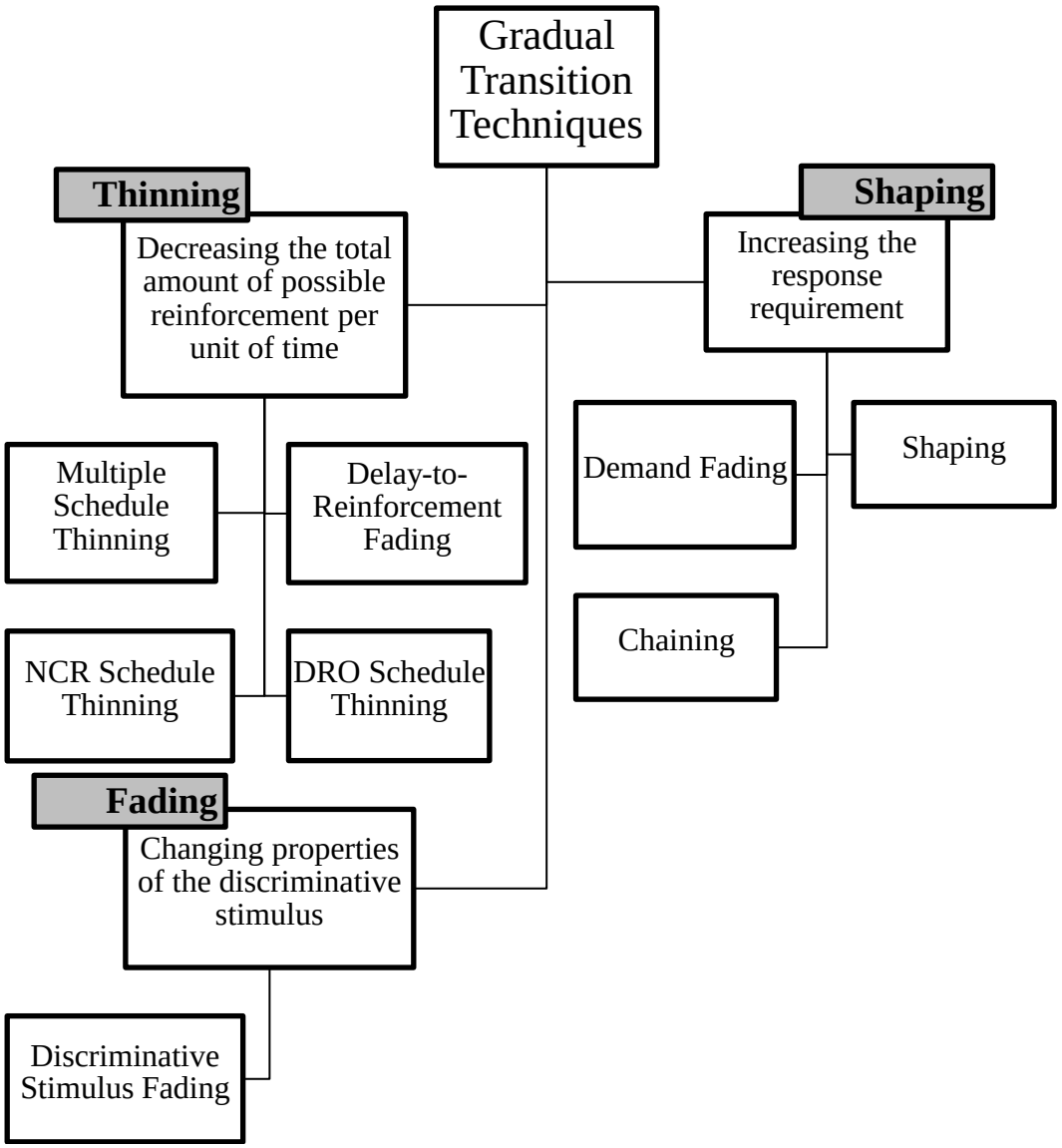

Figure 1. Flow chart of the proposed taxonomy of gradual transition techniques.