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TUTORIAL AND SYNTHESIS

Incorporating discriminative stimuli into functional communication training with augmentative and alternative communication devices: a tutorial

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ABSTRACT

Functional communication training (FCT) is a commonly used and effective treatment for problem behavior maintained by social reinforcement (e.g., an individual engages in self-injurious behavior to gain access to adult attention). FCT involves teaching an individual to emit an appropriate communication response to access the reinforcer maintaining problem behavior (e.g., pressing a "Play, please" symbol on a device to gain the communication partner's attention) and withholding that reinforcer following problem behavior (e.g., the communication partner minimizes attention-following problem behavior and waits for a communication response). Techniques such as incorporating discriminative stimuli (e.g., differently colored cards) can make FCT more practical for caregivers by teaching individuals when reinforcement is and is not available for communication responses while simultaneously mitigating treatment relapse. Despite the effectiveness of FCT with discriminative stimuli, no studies have leveraged the capabilities of augmentative and alternative communication (AAC) devices by embedding discriminative stimuli within AAC software (e.g., by coloring communication symbols or grids). Our tutorial provides a comprehensive overview of how practitioners can incorporate FCT with discriminative stimuli into practice and includes video models of how to design these treatments on two common AAC apps.

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Functional communication training

Individuals who engage in problem behavior (e.g., aggression, self-injurious behavior) often face significant barriers to learning, developing social relationships, and community integration (Antonacci, Manuel, & Davis, 2008), any of which may necessitate behavioral treatment. Behavior analysts use functional-analysis methodology (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994) to identify the reinforcer(s) maintaining such behavior (see Betz & Fisher, 2011; Iwata & Dozier, 2008). Behavior analysts then use the results of the functional analysis to develop function-based interventions, such as functional communication training (FCT). FCT is the most commonly implemented intervention for severe problem behavior (Tiger, Hanley, & Bruzek, 2008) and is highly effective at reducing problem behavior maintained by social reinforcement, such as access to adult attention, preferred items, escape from nonpreferred activities, or a combination thereof (Greer, Fisher, Saini, Owen, & Jones, 2016; Rooker, Jessel, Kurtz, & Hagopian, 2013).

During FCT, practitioners teach and reinforce an appropriate, functionally equivalent response called a functional communication response (hereby described as a *response*; e.g., pressing a symbol, exchanging a card) using the stimulus that previously maintained problem behavior (Carr & Durand, 1985). For example, if access to adult attention reinforced problem behavior, the practitioner may teach the individual to exchange a card containing an image of the two playing together in order to access adult attention. Commonly, practitioners combine FCT with extinction for problem behavior such that the response produces reinforcement exclusively. In the example above, adult attention would be minimized following problem behavior. Researchers have used FCT with extinction to rapidly reduce problem behavior and increase responses across a wide variety of populations, behaviors, settings, and response modalities (Greer et al., 2016; Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998; Rooker et al., 2013).

Reinforcement-schedule thinning with unsignaled delays

Although FCT with extinction is highly effective, continuous reinforcement of responses may lead to high rates of responses and reinforcement, which can be impractical for caregivers and other stakeholders. For example, an individual may continue to request attention while the caregiver communicates with the individual's physician or may request escape during math periods in a manner that stalls academic progress. Traditionally, practitioners have made FCT more practical by inserting progressively longer delays to reinforcement following the initial response, which decreases response rate and reinforcer deliveries (Fisher, Thompson, Hagopian, Bowman, & Krug, 2000). Although delayed reinforcement schedules can be effective in some cases

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(Hagopian et al., 1998), this strategy may extinguish responses at longer, more practical delay schedules because delays weaken the contingency between the response and reinforcement (Hanley, Iwata, & Thompson, 2001). Thus, delayed reinforcement schedules are often unsuccessful in reducing problem behavior to acceptable levels without the use of supplemental procedures (Hagopian et al., 1998; Rooker et al., 2013). In consecutive-case analyses of FCT, supplemental procedures refer to additional reinforcement (e.g., noncontingent activities during delay periods) or punishment components (e.g., restraints) during reinforcement-schedule thinning (Greer et al., 2016; Hagopian et al., 1998; Jessel, Ingvarsson, Metras, Kirk, & Whipple, 2018; Rooker et al., 2013).

Moreover, unsignaled delays to reinforcement generally fail to mitigate the recurrence of problem behavior (i.e., treatment relapse) when exposed to treatment challenges, such as prolonged periods of extinction for the response (e.g., Fuhrman, Fisher, & Greer, 2016). This susceptibility to treatment relapse is troubling because similar types of treatment challenges are likely to occur outside of the clinical context when reinforcement is temporarily unavailable, such as when tangible reinforcers become misplaced or compliance with instructions is necessary (e.g., during an evacuation). Relapse of problem behavior during FCT may, in turn, result in caregivers no longer implementing FCT as prescribed (e.g., by reinforcing problem behavior; Mitteer, Greer, Fisher, Briggs, & Wacker, 2018), which can worsen treatment outcomes by strengthening problem behavior (St. Peter Pipkin, Vollmer, & Sloman, 2010). As such, long-term success may require the development of treatments that mitigate the relapse of problem behavior.

Reinforcement-Schedule thinning with discriminative stimuli

To reduce the previously noted concerns, researchers have incorporated discriminative stimuli (e.g., two differently colored cards that serve as treatment signals) during FCT to signal the availability and unavailability of reinforcement for a given response. When using FCT with discriminative stimuli, practitioners correlate unique stimuli with at least two schedule components that alternate either strictly or loosely and according to a preset rule (e.g., no more than two successive presentations of the same component type). One component or the other is always in effect. Typically, this involves (a) a reinforcement component signaled by a discriminative stimulus (S^D; e.g., a green card) that indicates the availability of reinforcement for the response according to a continuous-reinforcement schedule and (b) an extinction component signaled by a delta stimulus (S^Δ; e.g., a red card) that indicates unavailability of reinforcement for the response (Saini, Miller, & Fisher, 2016). For social-positive reinforcers, such as attention or tangible items, this component involves waiting or tolerating periods without reinforcement (i.e., omission of responses), but for social-negative reinforcers, such as breaks from academic work, this component often also involves complying with instructions. These time-based or compliance-based treatments are described as FCT with multiple or chained schedules of reinforcement, respectively. An initial treatment might involve a 60-s S^D component and a brief S^Δ duration (e.g., 2 s for multiple schedules or one compliance for chained schedules; Greer et al., 2016). Once establishing discriminative control over responses (i.e., responses occur during the S^D component exclusively), practitioners can thin reinforcement by gradually increasing the S^Δ duration, relative to that of the S^D, with longer wait periods or more demands until reaching a terminal schedule (e.g., 10-min wait period, completion of 30 instructions).

FCT with discriminative stimuli is highly effective at thinning reinforcement both gradually (Greer et al., 2016) and rapidly by transitioning immediately from the initial schedule to the terminal schedule (Betz, Fisher, Roane, Mintz, & Owen, 2013; Fisher, Greer, Fuhrman, & Querim, 2015, Fuhrman et al., 2016), often without the need for supplemental procedures. The signaling effect of discriminative stimuli can greatly mitigate relapse produced by treatment challenges, such as prolonged periods of extinction (Fuhrman et al., 2016) or contextual changes (e.g., implementing FCT in novel situations; Fisher et al., 2015; Greer et al., 2019). When researchers have assessed individuals' preferences for the use of discriminative stimuli during FCT, individuals opted to experience FCT with discriminative stimuli (Luczynski & Hanley, 2014), perhaps because the discriminability of contingencies for the response (i.e., predictability) is improved when embedding such signals.

Implications for augmentative and alternative communication

Despite the impressive findings noted previously, to our knowledge, no research has focused on adapting these refinements to FCT when using augmentative and alternative communication (AAC) systems. AAC systems can be highly effective platforms through which practitioners can implement FCT (Walker, Lyon, Loman, & Sennott, 2018), and with the advent of mobile technology (e.g., iOS), communication apps are easily accessible and less cost-prohibitive than in the past (McNaughton & Light, 2013; Shane et al., 2012). Although FCT on AAC software can result in effective treatments, most researchers using AAC systems have not assessed the durability of FCT interventions with systematic evaluations of maintenance or generalization (Walker et al., 2018). In their meta-analysis, Schlosser and Lee (2000) found that over 90% of AAC studies analyzed relied on "train and hope" (Stokes & Baer, 1977, p. 351) strategies.

Though researchers have recently suggested using discriminative stimuli in conjunction with AAC systems (Byiers & Reichle, 2015), there have been no published materials teaching practitioners how to do so. Thus, the aim of this paper is to provide rationale and teaching materials for how to embed discriminative stimuli within AAC software when implementing FCT. Regardless of the AAC system, practitioners can program discriminative stimuli within AAC software easily (e.g., by coloring symbols, pages, or folders) as part of an individual's FCT intervention. Although dedicated devices are durable and insurance companies may purchase them for families, this tutorial will focus on commercially available apps for iOS because practitioners can leverage iOS's guided-access feature to prevent manipulation of parts of the screen (e.g., touching icons that close the communication app or switch components prematurely). Further, iOS software is widely available on affordable devices (e.g., iPad® or iPod Touch®[1]) that can be replaced quickly if broken or lost.

In our video models, we provide instructions for arranging FCT with discriminative stimuli on two iOS apps available for the iPad—Snap™ + Core First®[2] (Version 1.6.0.4487) and Proloquo2Go®[3](Version 5.5.1). We selected these apps because they are the most commonly prescribed apps by our Department of Speech-Language Pathology, have been used in the published FCT literature (e.g., Muharib & Alzrayer, 2018), and have settings conducive to embedding discriminative stimuli within the software. We created a video model for each FCT step when using AAC software, from generating the response to embedding discriminative stimuli, which correspond to the section headings below (see the appendix for hyperlinks to each video model). This tutorial is intended to be a primer for arranging discriminative stimuli on AAC software. Readers interested in specific teaching procedures and considerations for FCT should refer to published review articles and chapters on these topics (Byiers & Reichle, 2015; Greer & Fisher, 2017; Tiger et al., 2008). Although we have highlighted discriminative-stimuli procedures with high-tech AAC apps, we have also included descriptions of traditional discriminative-stimuli arrangements (e.g., colored discriminative stimuli, printed response cards) in the sections that follow that correspond with how practitioners using low-tech AAC (e.g., printed materials, communication boards) would implement these procedures.

Creating and teaching responses

Considerations for teaching responses

Prior to conducting reinforcement-schedule thinning with discriminative stimuli, practitioners teach the individual to emit the response to gain access to the reinforcer identified by the functional analysis as maintaining problem behavior. Practitioners consider many variables (e.g., response effort, proficiency, caregiver and individual preference) when selecting the response modality, often selecting a modality that is matched to the skills within the individual's repertoire (Horner & Day, 1991; Ringdahl et al., 2009). During initial teaching, practitioners should select a response that they can prompt quickly to minimize time without access to the reinforcer (i.e., the establishing operation for problem behavior). Decreasing motivation for the reinforcer helps to offset bursts of problem behavior in the early stages of FCT (DeRosa, Fisher, & Steege, 2015; Fisher et al., 2018). Commonly, practitioners use progressive-prompt delay procedures (Charlop, Schreibman, & Thibodeau, 1985) to teach the response in a multiple-trial format wherein each trial consists of the practitioner (a) presenting the relevant establishing operation for problem behavior, (b) immediately prompting the individual to emit the response, and (c) delivering the reinforcer immediately after the response. For example, for tangibly maintained problem behavior, the practitioner would restrict access to the tangible item, immediately prompt the response for the tangible item using a controlling prompt such as physically guiding the symbol press on the AAC interface or touching a printed card, and then deliver the tangible item immediately after the response. If the individual displays no problem behavior during these trials, the practitioner then increases the prompt delay gradually (e.g., 2 s, 5 s, 10 s, 20 s) to allow the individual opportunities to emit the response independently. Teaching in this way minimizes exposure to the establishing operation and thereby reduces the likelihood of problem behavior recurring. Teaching the activation of a symbol on a mobile device using an AAC app (e.g., touching a "Break" symbol), without requiring a frame (e.g., having to first press the "I want a… " symbol), is ideal because it requires minimal response effort and can be guided quickly, discouraging problem behavior during teaching. Commonly, practitioners evaluate the efficacy of FCT prior to reinforcement-schedule thinning using ABAB designs (i.e., baseline, FCT [following teaching of the response], baseline, FCT; Greer et al., 2016). This allows practitioners to be certain that increases in problem behavior during reinforcement-scheduling thinning are a result of increased exposure to the establishing operation during the S^{Δ} and not an ineffective FCT treatment, in general.

Teaching precise versus omnibus responses

In most cases, practitioners teach the individual to emit a precise response that specifies a single reinforcer (e.g., attention) in the presence of its establishing operation (e.g., attention deprivation). In our clinic, we often design response materials to include an image of the individual consuming the relevant reinforcer (e.g., an individual playing cards with an adult) with words relevant to the situation (e.g., "Play Cards") to make responses easily understandable to novel adults. Teaching a single response, rather than several responses simultaneously, may promote response acquisition.

There are cases, however, in which teaching a single response is insufficient. A functional analysis may reveal that problem behavior is maintained by multiple reinforcers (e.g., access to escape and attention). In these cases, teaching a response that provides access to only one reinforcer (e.g., escape) may not adequately reduce problem behavior if other reinforcers (e.g., attention) remain unavailable (Bachmeyer et al., 2009). In these situations, practitioners may opt to teach a response that produces access to multiple reinforcers simultaneously, also known as an omnibus

[1]The iPad and iPod Touch are products of Apple Computers Inc., Cupertino, CA, USA. www.apple.com

[2]Snap + Core First is a product of Tobii Dynavox LLC, Pittsburgh, PA, USA. www.tobiidynavox.com

[3]Proloquo2Go is a product of AssistiveWare B. V., Laurierstraat, Amsterdam, NL. www.assistiveware.com

response (Jessel et al., 2018; Mitteer, Fisher, Briggs, Greer, & Hardee, 2019). For example, Mitteer et al. conducted a functional analysis with two children and observed elevated rates of problem behavior in the attention, tangible, and escape conditions relative to a common control condition. To reduce problem behavior quickly and strengthen communication skills, Mitteer et al. taught both children to exchange a response card to access all three reinforcers simultaneously (i.e., a break with attention and tangibles) before later using other strategies to generate more precise responses. In this case, the omnibus response card read, "My way," and the image depicted the child playing with the communication partner and tangible items as the adult pushed the bin of work materials away from the child.

Creating and teaching responses on AAC apps

The flexible format of mobile devices with AAC apps allows practitioners to use either strategy to quickly generate an initial response. However, it is unlikely that practitioners and families would invest in an AAC app to teach only one communication response; rather, AAC apps are ideal for organizing numerous communication responses in a single location on the display. Prior to presenting multiple responses together (e.g., symbol for tangibles and a separate symbol for attention), it may be helpful to assess the individual's simultaneous-discrimination skills. A simultaneous discrimination involves differentiated responding between two or more concurrently available stimuli and, in the case of FCT, is often assessed by presenting distractor stimuli (e.g., blank symbols) simultaneously with a response symbol (Akers et al., 2019; Fisher, Greer, Querim, & DeRosa, 2014). This can be done in most AAC apps by presenting the response and distractors in a grid display (e.g., 2×2 grid) or presenting printed response cards in a similar layout. By determining whether an individual can discriminate between a response that produces reinforcement and distractors that do not, practitioners can be more confident that future responding toward one response (e.g., for tangible items) over another (e.g., for adult attention) when those responses are presented simultaneously reflects differences in relative value of the two reinforcers rather than poor stimulus control. Further, by rotating the arrangement of the responses quasirandomly (e.g., the response is presented in the top-left of a 2×2 grid on some trials and in the other three grid positions on other trials), practitioners can minimize the development of faulty stimulus control by response location. This helps ensure that the responses are under the control of the visual representation of the symbol (and its associated contingencies), rather than simply the symbol's location.

If the practitioner opts to teach an omnibus response first, we recommend later teaching each response separately and under relevant motivating conditions (e.g., teaching the response for adult attention in a context without demands but with tangible items) prior to presenting the responses simultaneously. Practitioners can use the above procedures to generate precise responses, such as for specific types of attention (e.g., tag, hide-and-go-seek) or tangible items (e.g., iPad, toy cars) within a single grid. Teaching separate responses after acquisition of an omnibus response may circumvent later treatment relapse related to the changing availability of one or more of the reinforcers produced by the omnibus response (e.g., if the tangible item is available but adult attention is not; Mitteer et al., 2019).

Creating and using discriminative stimuli

Considerations for using discriminative stimuli during FCT

Recall that the primary feature of FCT with discriminative stimuli is the use of salient signals that correlate with different contingencies for the response. Most commonly, practitioners alternate between a reinforcement (S^D) component (e.g., signaled by a green stimulus) and an extinction (S^Δ) component (e.g., signaled by a red stimulus), with the termination of the latter component dependent upon either the passage of time (multiple schedule) or compliance with instructions (chained schedule; Saini et al., 2016). Researchers have used a variety of schedule-correlated stimuli worn by the practitioner or target individual (e.g., wristbands, index cards attached to lanyards) or positioned within the teaching setting (e.g., a poster board adhered to the wall) as discriminative stimuli during FCT (Saini et al., 2016). Often, practitioners create discriminative stimuli based on the presenting characteristics of the individual, such as color biases or color blindness and other visual impairments (e.g., by using patterns like checks and stripes rather than colors). With AAC apps, practitioners can program discriminative stimuli directly onto the display by coloring grids or symbols (e.g., a green or red grid color for the S^D or S^Δ, respectively).

As mentioned previously, practitioners often begin with a longer S^D duration (e.g., 60 s) and a brief S^Δ duration (e.g., 2 s for multiple schedules or one response requirement for chained schedules). During multiple schedules, S^Δ components commonly involve the individual waiting (i.e., not engaging in responses or problem behavior) and can involve access to alternative activities (e.g., low-preferred toys; Fuhrman, Greer, Zangrillo, & Fisher, 2018) but such interventions are effective even when individuals wait with nothing (Greer et al., 2016), emulating times in which alternative activities are unavailable. During chained schedules, S^Δ components often involve practitioners implementing guided compliance procedures (i.e., physically guiding compliance if it does not occur following the adult's instructions; Horner & Keilitz, 1975) until the individual complies independently with the instructions.

By starting with short S^Δ durations, practitioners limit the opportunity for responses to occur and contact extinction, which may offset bursts of problem behavior. Once responses occur during the S^D component exclusively, and problem behavior remains low (and, in the case of chained schedules, compliance remains high), practitioners can thin reinforcement by gradually increasing the S^Δ duration relative to that of the S^D by requiring the individual to wait longer (e.g., 5 s, 10 s, 15 s, 30 s, 60 s) or complete more work (e.g., two instances of compliance, four instances of compliance, eight instances of compliance) until the individual meets the terminal schedule (e.g., 240 s; 30 instances of compliance). Practitioners present these components quasi-randomly (e.g., S^D, S^Δ, S^Δ, S^D) such that emission of responses comes under the control of the programmed stimuli rather than the stimulus change (e.g., the practitioner manipulating the discriminative stimuli on the AAC device). Other procedures our clinic uses to facilitate the discrimination between the S^D and S^Δ include: (a) programming reinforcer durations shorter than the S^D component (e.g., 20 s reinforcer durations during 60-s S^D) to allow for multiple learning opportunities during the S^D (e.g., Fuhrman et al., 2016), (b) including a brief (e.g., 3 s) changeover delay (Herrnstein, 1961) following problem behavior or responses during the S^Δ before switching to the S^D to avoid inadvertently reinforcing those responses with the presentation of the S^D (e.g., Greer et al., 2016), and (c) including response-blocking of responses during the S^Δ and prompting of responses during the S^D (e.g., Akers et al., 2019) or incorporating verbal rules about the contingencies related to each stimulus during initial discrimination training (Fuhrman et al., 2016).

Signaling the availability of multiple reinforcers simultaneously

Although approximately 98% of studies involving discriminative stimuli have used two-component arrangements (Saini et al., 2016), multiple and chained schedules can include three or more components to signal the availability of some, but not all, reinforcers at a given time. For example, blue, yellow, green, and red grid backgrounds could signal the availability of reinforcement for (a) the attention response, (b) the tangible response, (c) attention and tangible responses, and (d) none of the responses, respectively. See Akers et al. (2019) and Mitteer et al. (2019) for recent examples of such arrangements. Alternatively, practitioners can signal the availability of each reinforcer by modifying the color of symbols as availability changes, such as changing symbols for unavailable reinforcers from red to green as they become available.

Conducting response restriction and stimulus fading

Response restriction

Some individuals may not readily discriminate between symbols or between schedule components by responding appropriately in the presence of schedule-correlated stimuli. As noted previously, when responses contact extinction, this results in a worsening of reinforcement conditions that can lead to relapse of problem behavior (Fuhrman et al., 2016). In these situations, practitioners may implement response restriction, which involves removing access to communication materials (e.g., symbols on the mobile device with an AAC app; low-tech physical response cards) when reinforcement is unavailable to limit excessively high-rate responses while maintaining low levels of destructive behavior (Fisher et al., 2014; Greer et al., 2016; Hagopian, Boelter, & Jarmolowicz, 2011). FCT with response restriction has been highly effective at (a) eliminating destructive behavior, (b) limiting excessively high-rate and inefficient responses, and (c) maintaining the strength of the responses (i.e., the individual continues to respond when the communication materials are available; Fisher et al., 2014; Greer et al., 2016).

Stimulus fading

Though FCT with response restriction is sometimes a terminal-treatment arrangement (e.g., Greer et al., 2016), response restriction may serve as the first step of stimulus fading in which a response correlated with extinction is first absent but later introduced and gradually increased in salience. Practitioners can use this process of stimulus fading to introduce a distractor symbol or card or to transition from response restriction to a situation in which the response remains available during periods of extinction previously associated with continued use of the response, resulting in excessively high-rate responses. As a form of errorless learning, the practitioner alters dimensions of the symbol or card correlated with extinction, such as its size and location relative to others in such small steps so as not to occasion excessive incorrect responding. For example, Fisher et al. (2014) taught children to discriminate between a response card (e.g., to access a break from nonpreferred demands) and a distractor card (e.g., a black card that did not produce a break) by gradually increasing the distractor card's size (i.e., from 3.3 cm by 4.8 cm to 14 cm by 21.6 cm) and adjusting its location (i.e., from a position of 10 cm to 15 cm away from the response card to a position equidistant to the response card) as the children continued to exchange only the response card for escape.

Akers et al. (2019) conducted a similar stimulus-fading approach with a response card for edibles and a distractor card, as well as a response card for beverages and a distractor card. Then, Akers et al. implemented additional stimulus fading within the context of a four-component multiple schedule in which they presented all three cards and correlated one of four colored poster boards with (a) reinforcement for the edible response, (b) reinforcement for the beverage response, (c) reinforcement for both responses, or (d) reinforcement for neither response. Exchanges of the distractor card always resulted in extinction, and the four components alternated in a quasi-random order, such that one component, and its associated poster-board color, was always in effect. Across therapy sessions, Akers et al. introduced and gradually increased the size of the cards correlated with extinction within each of the four components, beginning with response restriction and then progressing through a six-step fading sequence until the child was emitting only the responses correlated with reinforcement in each reinforcement component of the multiple schedule. Please refer to Akers et al. for more information.

Response restriction and stimulus fading on AAC apps

Practitioners can adapt AAC apps to incorporate similar stimulus-fading procedures, which may be less cumbersome than preparing printed materials (e.g., differently sized response cards), as done in previous studies. For example, practitioners may wish to teach an individual to avoid touching a response symbol when the S^{Δ} is present, as indicated by a red-colored grid. One stimulus-fading option would be to first remove the symbol completely during the S^{Δ} component, then present a small version of the symbol furthest from the individual's hand placement, perhaps colored red to be translucent with the red-colored grid, and then gradually increase the size of the symbol, reduce its distance from the individual's hand, and lighten the symbol's background color until it appears as initially programmed on the S^{Δ}.

Conclusion

Researchers have refined FCT interventions by using discriminative stimuli to thin reinforcement schedules for responses rapidly (Betz et al., 2013; Fuhrman et al., 2016), reduce the need for supplemental procedures during reinforcement-schedule thinning (Greer et al., 2016), and mitigate the relapse of problem behavior during common treatment challenges (Fuhrman et al., 2016). Despite researchers implementing FCT with AAC systems for decades (Durand, 1993; Mirenda, 1997; Schlosser, 1997; Walker et al., 2018), there have been no published studies to our knowledge that have leveraged the capabilities of AAC systems to embed discriminative stimuli within the AAC app during FCT. In this paper, we provided an overview of how these FCT procedures are conducted without AAC app, a description of how practitioners might arrange these treatment components within AAC systems, and video models to teach practitioners how to create various FCT arrangements within commonly used AAC apps. Our hope is that the combination of general instruction and specific video models will assist practitioners in adapting current and future AAC apps to empirically supported refinements to FCT, even if using different AAC devices or apps.

To summarize, the general treatment progression should be as follows. First, the practitioner should conduct a functional assessment (ideally a functional analysis) of the target problem behavior. Second, the practitioner should create a response symbol within the AAC display that corresponds to the identified reinforcer maintaining problem behavior. The practitioner should use best-practice procedures (e.g., progressive-prompt delay) to minimize the occurrence of problem behavior while the individual acquires the response in the presence of the respective establishing operation. In cases of multiply controlled problem behavior (e.g., problem behavior reinforced by escape and tangibles), the practitioner should consider teaching either multiple precise responses or an omnibus response to address all relevant establishing operations. Third, the practitioner should ensure that FCT is effective at reducing problem behavior prior to reinforcement-schedule thinning using single-case experimental designs such as an ABAB design; if FCT fails to reduce problem behavior relative to baseline, the practitioner should conduct further analyses to improve its efficacy (e.g., isolating and addressing untargeted establishing operations, increasing reinforcer magnitude). Fourth, in the case of multiple responses, the practitioner should assess simultaneous-discrimination skills to ensure that the individual can emit responses accurately in the presence of the relevant establishing operation and nontarget symbols. Fifth, the practitioner should thin reinforcement for each response by embedding discriminative stimuli into the response symbols or AAC grid and beginning discrimination training using best-practice procedures (e.g., initially short exposures to the S^{Δ}, changeover delay for responses during the S^{Δ}). The practitioner should thin reinforcement following low levels of problem behavior and highly discriminated responses (i.e., responses occurring during the S^{D} exclusively) and, in the case of chained schedules, high levels of compliance (e.g., 80% compliance with instructions). The practitioner should use response restriction and stimulus fading as remedial strategies for teaching discrimination amongst responses or discriminative stimuli. The practitioner should continue to teach new symbols and incorporate discriminative stimuli as the individual encounters novel reinforcers (e.g., playground). Finally, the practitioner should assess maintenance and generalization of treatment effects to ensure that the treatment will remain durable over time and across novel settings, implementers, and other treatment challenges.

Although we have described intervention procedures as they relate to the treatment of problem behavior, it is important to note that these procedures are not limited to the treatment of severe problem behavior exclusively. Indeed, researchers have used multiple schedules to signal the availability of reinforcers such as teacher attention (Grow, LeBlanc, & Carr, 2010; Luczynski & Hanley, 2014; Tiger, Hanley, & Larsen, 2008) and edibles (Sidener, Shabani, Carr, & Roland, 2006) with children who do not exhibit problem behavior. Because practitioners can thin reinforcement for responses rapidly once they establish stimulus control over them, our video models may be helpful for improving the practicality of AAC interventions for any individual who requests reinforcers at high rates or during periods of nonreinforcement. Practitioners can use the aforementioned treatment progression to leverage discriminative stimuli on AAC apps while omitting the functional assessment and focusing exclusively on discrimination of requests (and compliance, if using a chained schedule) when thinning reinforcement.

As a final note, it is important to highlight that, despite FCT with discriminative stimuli having broad empirical support across various response modalities and types of discriminative stimuli, formal evaluations of these procedures on AAC devices are needed to demonstrate their efficacy. We hope this tutorial will not only facilitate research uptake in practice but also spur additional research on this topic to support the use of discriminative stimuli within AAC interventions, such as large-n studies evaluating the effects using discriminative stimuli within AAC systems during FCT (similar to the controlled consecutive-case series published by Greer et al., 2016) and within-subject comparisons of FCT interventions in which AAC devices do and do not embed discriminative stimuli.

Disclosure statement

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Appendix

List of Video Model Hyperlinks.

Snap + Core First

1. User Profile (https://youtu.be/RaZZN6Uz60M).
2. Single Response & Two-Component Schedule (https://youtu.be/NVSiQt9hLsA).
3. Multiple Responses & Three + Component Schedule (https://youtu.be/LGSEGWqFnfl).
4. Response Restriction & Stimulus Fading (https://youtu.be/yt79fxQA4rl).
5. Using Guided Access on iOS (https://youtu.be/yzZeDCM1dzQ)*.

Proloquo2Go

1. User Profile (https://youtu.be/q-1R63NHhsw).
2. Single Response & Two-Component Schedule (https://youtu.be/NdrdcKvY3uA).
3. Multiple Responses & Three + Component Schedule (https://youtu.be/CIGYUsi7Gic).
4. Response Restriction & Stimulus Fading (https://youtu.be/DEOlfqUWs1I).
5. Using Guided Access on iOS (https://youtu.be/yzZeDCM1dzQ).

* Although guided access is shown with Proloquo2Go only, this iOS feature is identical on Snap + Core First.