Shaping complex functional communication responses: SHAPING COMPLEX COMMUNICATION RESPONSES

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SHAPING COMPLEX FUNCTIONAL COMMUNICATION RESPONSES

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Response efficiency plays an important role in the initial success of functional communication training (FCT). Although low-effort functional communication responses (FCRs) have been shown to be most effective in replacing problem behavior; more developmentally advanced FCRs are favored later in the treatment process. Attempts to teach these more complex FCRs, however, often lead to the resurgence of problem behavior. In this study, we provide a detailed description of an effective shaping process applied within a changing criterion design to develop complex FCRs from simple FCRs without resurgence of problem behavior. Four children with various language and intellectual abilities participated in this study. A practical shaping procedure, suitable for typical teaching contexts, is described for two participants in Experiment 1. The necessity and efficacy of the shaping process are demonstrated with the participants in Experiment 2. Implications for practice and research are discussed.

Key words: autism, functional communication training, interview-informed synthesized-contingency analysis, problem behavior, shaping

Functional communication training (FCT) is an efficacious treatment that results in substantial reductions of problem behavior (Durand, & Moskowitz, 2015; Tiger, Hanley, & Bruzek, 2008). With FCT, a socially appropriate response that serves the same function as problem behavior is taught via prompting and a rich schedule of reinforcement to eliminate problem behavior. Horner and Day (1991) demonstrated that the new functional communication response (FCR) may not occur in lieu of problem behavior unless this new response is more efficient than the problem behavior. According to Horner and Day, response efficiency is affected by the amount of effort required to emit a response and the schedule and immediacy of reinforcement for that response. For instance, Horner and Day found that a one-word (low-effort) response was more effective than a full-sentence (high-effort) response. The importance of the efficiency of FCRs has been replicated across various modalities (e.g., Buckley & Newchok, 2005; Richman, Wacker, and Winborn, 2001), and the least effortful response has been the most effective in every case. Although these results have led to the recommendation that low-effort responses be identified and selected as the target FCR (Ringdahl et al., 2009; Tiger et al., 2008), there is also some evidence suggesting that more

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complex FCRs, such as those that include an autoclitic frame (e.g., “May I have the toy, please”) may lead to better generalization and emergence of novel mands (Hernandez, Hanley, Ingvarsson, & Tiger, 2007). For these reasons, Tiger et al. (2008) recommended that simple, low-effort responses only be used as the initial FCR and more complex FCRs eventually shaped.

Teaching more complex FCRs that involve obtaining a listener’s attention, making eye-contact, ensuring acknowledgement, and adding an autoclitic frame and a social nicety may also be more consistent with the general goal of addressing the common social and communicative deficits of children and adults with severe problem behavior, especially those with autism (Hwang & Hughes, 2000; Macintosh & Dissanayake, 2006). Complex FCRs that are developmentally and socially appropriate could also be more acceptable and recognizable to peers and novel adults (Durand & Carr, 1992), which may increase the generality, social validity, and overall effectiveness of FCT. The detrimental effects of response effort, however, must be mitigated for these benefits to be realized.

Despite the recommendations by Tiger et al. (2008), and the potential benefits of more complex communication responses, there is a lack of clarity on how to mitigate the potential side effects of increased response effort as very few studies of FCT have included a transition from simple FCRs to more complex forms. A two-step approach of moving from a simple FCR (“My way”) to one of greater complexity (e.g., “Excuse me? [pause] May I have my way, please?”) was briefly described by Hanley, Jin, Vanselow, and Hanratty (2014) and replicated in Santiago, Hanley, Moore, and Jin (2016). In these studies, the authors taught more complex FCRs by expanding the class of responses that were placed on extinction to include both problem behavior and the simpler form of the FCR. This two-step process, however, may lead to resurgence of problem behavior, as it did for two of three children in Hanley et al. and both children in Santiago et al., or an extinction burst in some cases. Resurgence of problem behavior may reduce the social acceptability of these procedures when applied in relevant contexts or may punish the change agent’s attempts to develop a socially and developmentally appropriate FCR. Progression from a simple response to one of greater complexity may require a more deliberate and gradual shaping of the complex response to prevent the resurgence of problem behavior.

In addition to response effort, response efficiency also depends on the schedule and immediacy of reinforcement (Horner & Day, 1991). Horner and Day found that the shorter the time delay between the presentation of the discriminative stimulus and the delivery of reinforcement, the more efficient the response. Similarly, Derosa, Fisher, and Steege (2015) and Fisher et al. (2018) found that communication response topographies that allow for a shorter duration of exposure to the establishing operations (EO) result in larger and more rapid reductions in problem behavior and decrease the likelihood of an extinction burst. For example, a picture-exchange communication response can be prompted more quickly and reliably than a vocal communication response, thereby reducing the amount of EO exposure. More complex and multicomponent FCRs, such as the one modeled by Hanley et al. (2014), will also result in a longer delay to reinforcement and thus a longer exposure to the evocative context. Therefore, in addition to the effects of increased effort, the detrimental effects of the longer delay to reinforcement on the efficiency of the FCR should be considered. One way to address this issue would be to gradually fade in the full presentation of the evocative context. For example, as closer approximations of the target FCR are shaped and emitted to the exclusion of problem behavior, longer and more challenging durations of the evocative context could be presented.

Finally, the magnitude of reinforcement may play a role in increasing response efficiency, and manipulations of magnitude in favor of the more effortful response may increase the probability of that response. For example, Athens and Vollmer (2010) demonstrated that providing longer durations of reinforcement for appropriate communication than for problem behavior resulted in a decrease in problem behavior and an increase in appropriate communication without the use of extinction. It may be possible to counter the effects of response effort and the increased delay inherent in emitting a more complex FCR by increasing the duration or quality of reinforcement delivered contingent on these more complex responses.

In this study, we describe a set of experiments evaluating the efficacy of a shaping procedure for increasing the complexity of communication responses while minimizing the negative side effects of the process, such as the resurgence of problem behavior. In addition to increasing the complexity of the FCR, we also increased the EO exposure at each level and increased the duration of reinforcement as the complexity of the FCR was increased.

EXPERIMENT 1

In the first experiment, we used a shaping procedure for progressing from simple to complex FCRs during FCT for the treatment of the highly impulsive (i.e., short latency to problem behavior upon removal of reinforcers) problem behavior of two children with developmental disabilities who communicated using age-appropriate vocal language. Differential reinforcement and extinction were used to shape approximations of a complex communication response that included a two-part autoclitic frame, appropriate volume and tone of voice, eye-contact, and a pause for acknowledgement. The criterion for reinforcement was gradually increased to include more dimensions of the target response while exposing the participant to a more complete presentation of the evocative context and included within-session most-to-least prompting of the target FCR. The efficacy of this shaping procedure for increasing the complexity of FCRs without a resurgence of problem behavior or highly emotional responding was evaluated in a changing criterion design.

Method

Participants and setting. Two children referred to a university-based outpatient clinic for assessment and treatment of their severe problem behavior participated. Jian was a 4-year-old boy with a diagnosis of attention deficit/hyperactivity disorder (ADHD) who engaged in daily episodes of highly disruptive tantrums that included property destruction and aggression. Jeff was a 6-year-old boy with a diagnosis of Asperger's disorder, ADHD, and generalized anxiety disorder. Jeff engaged in daily episodes of highly emotional tantrums that included physical and vocal disruptions, aggression, and self-injury. The severity and highly emotional nature of these tantrums had resulted in Jeff spending all of his time with his mother and not participating in any formal instructional contexts such as kindergarten. Both children had age-appropriate language (i.e., full fluent sentences) and play skills and could follow multistep vocal instructions.

All sessions for Jian and Jeff were conducted in 4-m by 3-m treatment rooms equipped with a one-way mirror, audio/video equipment, child-sized tables, chairs, and academic and play materials. Sessions were conducted 2 to 3 days per week, two to six times each day. Sessions were 3 to 5 min during functional analyses and 5 min during FCT.

Measurement and interobserver agreement (IOA). Counts of problem behavior and FCRs were collected within 10-s intervals via laptop computers and converted to a rate. Problem behavior for Jian and Jeff included *aggression* (hitting, biting, kicking, head-butting, and pushing) and *disruptions* (physical disruptions such as throwing, ripping, swiping, and pushing items, and vocal disruptions such as a high-pitch scream). Problem behavior for Jeff also included *self-injury* (hand to head or hand to thigh hits).

Table 1 summarizes the FCR topographies and the manner of the presentation of the evocative context at each step. FCRs were considered prompted if the analyst prompted any aspect of the FCR within 10 s of the child's FCR. Only independent FCRs are reported.

Interobserver agreement (IOA) was assessed by having a second observer collect data on all targets simultaneously but independently during at least 20% of each phase for both participants. Records were compared on an interval-by-interval basis, and agreement percentages were calculated by dividing the smaller number of responses in each 10-s interval by the larger number. IOA for problem behavior and FCRs averaged 99.5% (range, 95%-100%) and 98% (range, 87%-100%) during the functional analysis and 99% (range, 92%-100%) and 99.5% (range, 93%-100%) during the treatment analysis, for Jian and Jeff, respectively.

Functional assessment process. An open-ended functional assessment interview (Hanley, 2012) was conducted for 45 min with each participant's parents to discover the related topographies of problem behavior and possible reinforcement contingencies. A 20-min interactive observation of each child in the session room followed (Hanley et al., 2014). An interview-informed, synthesized-contingency analysis (IISCA) was then conducted, which involved a rapid alternation of test and control

Table 1
Criteria for Each Functional Communication Response (FCR) Topography and Manner of Presentation of the Evocative Context for Jian, Jeff, and Luke

Steps	FCR Criterion for Reinforcement	Evocative Context Presentation (Jian and Jeff)	Evocative Context Presentation (Luke)
1	A vocal mand in a sentence fragment; no calm voice requirement *"My way please"*	Touched, but did not remove, preferred items. Simultaneously presented a vocal demand, stopped granting child's requests, and withheld Mom's attention.	Hovered hands over preferred items. Simultaneously presented a vocal demand, stopped granting child's requests, and withheld attention.
2	A vocal mand in an autoclitic frame with a calm voice *"May I have my way please?"*	Touched, but did not remove, preferred items. Simultaneously presented a vocal demand, stopped granting child's requests, and withheld Mom's attention.	Hovered hands over preferred items. Simultaneously presented a vocal demand, stopped granting child's requests, and withheld attention.
3	A vocal mand in an autoclitic frame with a calm voice and with an attention-seeking response requiring some eye-contact with the listener *"Excuse me may I have my way please?"*	Touched and slightly moved preferred items toward analyst. Simultaneously presented a vocal demand, stopped granting child's requests, and withheld Mom's attention.	Touched, but did not remove, preferred items. Simultaneously presented a vocal demand, stopped granting child's requests, and withheld attention.
4	A two-part vocal mand in an autoclitic frame with a calm voice and with an attention-seeking response requiring some eye-contact with the listener while pausing for acknowledgement from the listener before emitting the second part of the mand *"Excuse me?"[pause to receive acknowledgement]* *"May I have my way please?"*	Removed preferred items while looking away from the child. Simultaneously presented a vocal demand, stopped granting child's requests, and withheld Mom's attention	Removed preferred items while looking away from the child. Simultaneously presented a vocal demand, stopped granting child's requests, and withheld attention

sessions in which the suspected reinforcement contingency was present and absent, respectively (Hanley et al.).

The results of the interview and observation suggested that Jian's problem behavior was evoked when his preferred activities were interrupted with a demand to engage in a different task or to engage differently with the same task, or when an adult did not comply with his requests. Given that problem behavior resulted in the simultaneous delivery of escape from adult instructions, and access to attention, compliance with Jian's mands, and resumption of his activity, a synthesized contingency was tested for Jian. During the control condition, Jian was given uninterrupted access to his preferred activities, the analyst provided undivided attention without presenting any demands, and compliance was granted for all of his reasonable requests. During the test condition, the analyst interrupted Jian's play, delivered demands via three-step prompting, and ignored his requests. Contingent on any instance of problem behavior, the analyst removed the demands, allowed Jian to resume his activity in the manner that he preferred, attended to his activity, and honored his requests for 30 s.

The results of the interview and observation suggested a similar synthesized contingency for Jeff, except that the interview also suggested that attention from his mother, in particular, was important. Therefore, his mother's attention was continuously available during control sessions and available for 30 s contingent on problem behavior during test sessions. All other details of the analysis remained the same as Jian's, albeit with a different set of preferred activities.

Treatment process. The test sessions from the IISCA served as baseline. Following baseline, the complexity and difficulty of the FCR and the evocative context was increased in four steps along the dimensions noted in Table 1. Access to all reinforcers was provided for 1 min prior to each session. About every fourth session, children were allowed to select three to four different activities for the session from an array of preferred activities nominated by parents. Each session started with the presentation of the evocative context as described in Table 1.

Prior to the introduction of each step, the analyst specified the new contingency (e.g., Step 1 requirements) through verbal instruction and engaged in one practice trial followed by the immediate reinforcement of the prompted FCR prior to the session. Most-to-least prompting starting with immediate full vocal prompts was used during the session to teach the target FCR. Prompts included specification and modeling of the various dimensions of the response (e.g., calm voice, waiting for acknowledgement, eye-contact) as necessary. Reinforcers were withheld and prompts were repeated as necessary until the child responded to the prompt. When 80% of FCRs were independent in one session, full vocal prompts were provided every 60 to 90 s, if needed (this rarely occurred).

During Step 1, each target FCR, as well as any instance of a higher level FCR, was reinforced immediately; the reinforcement interval was 30 s. Problem behavior was placed on extinction. The reinforcement interval was increased to 60 s starting with Step 2. As the criterion was increased with each step, problem behavior and all prior, simpler topographies of FCR were placed on extinction. The next criterion was introduced following two (Jian; Step 1 and 2 only) or four consecutive sessions of stable responding (i.e., near-optimal levels of the target FCR and near-zero rates of problem behavior).

Results and Discussion

Both Jian's and Jeff's problem behavior was sensitive to a context that included a synthesis of social positive and negative reinforcers, as problem behavior was observed exclusively in the test sessions in which it terminated adult demands and yielded access to tangibles, attention, and compliance with requests (Figure 1). Both children emitted problem behavior within 2 to 5 s of the imposition of the EO in each test session.

During FCT, the optimal level of independent FCRs was approximately two instances per minute when the reinforcement interval was 30 s (Step 1), and one response per minute when the reinforcement interval was increased to 60 s (Step 2 onwards). Although prompted FCRs are not depicted, the provision of prompts can be gleaned from the lower-than-optimal rate of independent FCRs (e.g., session 15 for Jian).

There was an immediate reduction in Jian's problem behavior and near-optimal rates of FCRs with FCT at the first criterion (Figure 2). When the second criterion was introduced, zero rates of problem behavior continued, Step 1 FCRs were quickly eliminated, and Step 2 FCRs increased to optimal levels. Step 3 FCRs were initially emitted at optimal rates, but there was a brief recovery of problem behavior and Step 1 FCRs, followed by a subsequent loss of all FCRs. We returned to the previous criterion, regained optimal rates of Step 2 FCRs with zero rates of Step 1 FCRs and near-zero rates of problem behavior. After four sessions of stability, the criterion was once again increased, resulting in optimal levels of Step 3 FCRs, and near-zero rates of prior FCRs and problem behavior. The final criterion resulted in a gradual increase of Step 4 FCRs and a gradual decrease of Step 3 FCRs, while maintaining zero rates of problem behavior and prior FCRs.

Based on Jian's analysis, a minimum of four sessions of stable responding at each criterion was used throughout Jeff's analysis before changing criteria. Step 1 resulted in a temporary increase of problem behavior (Figure 3) and crying. These extinction phenomena were quickly eliminated, however, as Step 1 FCRs were acquired and emitted at the optimal level. Responding then closely conformed to each subsequent criterion in that the target FCRs occurred at optimal rates, while problem behavior and prior FCRs occurred at or near zero.

For both children, we were able to shape simple FCRs into more complex and developmentally appropriate FCRs, while maintaining near-zero rates of problem behavior (89% and 81% of sessions with zero problem behavior for Jian and Jeff, respectively). The changing criterion design was a practical tool for demonstrating the effects of the shaping process. Across 12 criteria, responding conformed to the target criterion in 11 out of 12 instances.

EXPERIMENT 2

Although the participants in Experiment 1 acquired the complex FCRs without much problem behavior, the extent to which the more

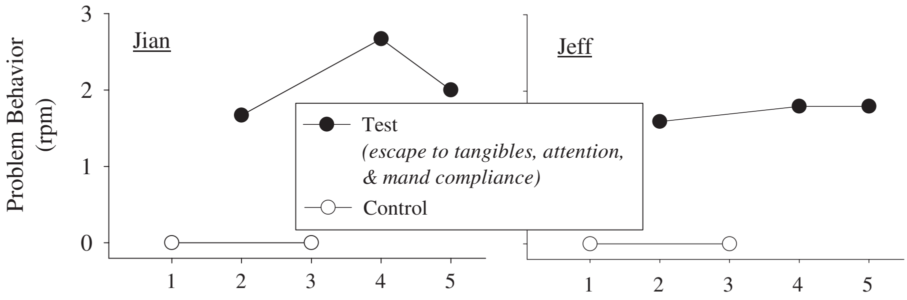

Figure 1. IISCA results for Jian and Jeff. Rpm = responses per minute.

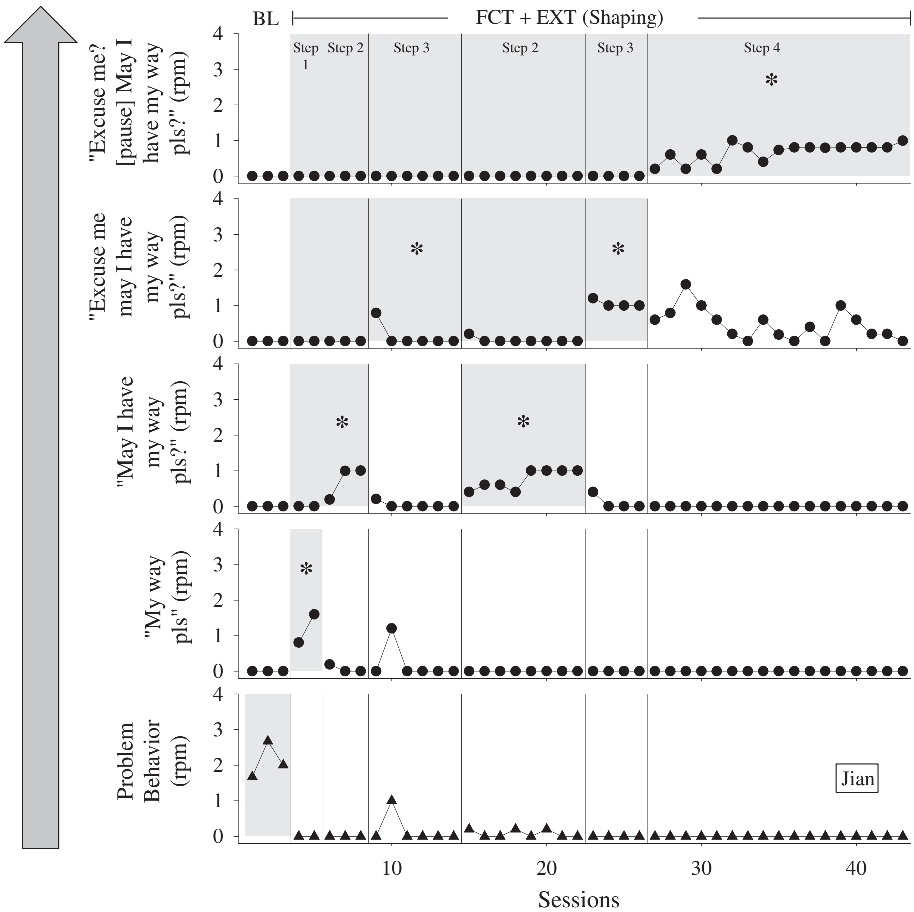

Figure 2. Results of the shaping procedure during FCT for Jian. Panels are to be read from bottom to top as indicated by the arrow to the left. The asterisks indicate the FCR topography targeted during each shaping phase, although only independent responses are depicted in each panel. The grey shaded area depicts the topographies that are reinforced during that phase.

gradual shaping procedure was in fact necessary for achieving these results is unclear. That is, we do not know if problem behavior would have remained low and the complex FCRs would have been acquired had we introduced the complex FCR immediately or in a two-step procedure as modeled by Hanley et al. (2014). The necessity of this shaping procedure may be called into question given the participants' language abilities and instruction-following skills (they both had fluent vocal verbal behavior and could follow two-step instructions). Furthermore, the generality of the effect is unclear. For example, the extent to which this more gradual shaping procedure would be efficacious for individuals without age-appropriate language or instruction-following skills remains to be evaluated. For these reasons, we replicated these procedures with two additional participants in Experiment 2, one with similar characteristics to the participants in Experiment 1 and one with limited expressive and receptive language. We also added terminal topography probes of the target complex FCR prior to the introduction of each shaping step to evaluate the necessity of the shaping procedure.

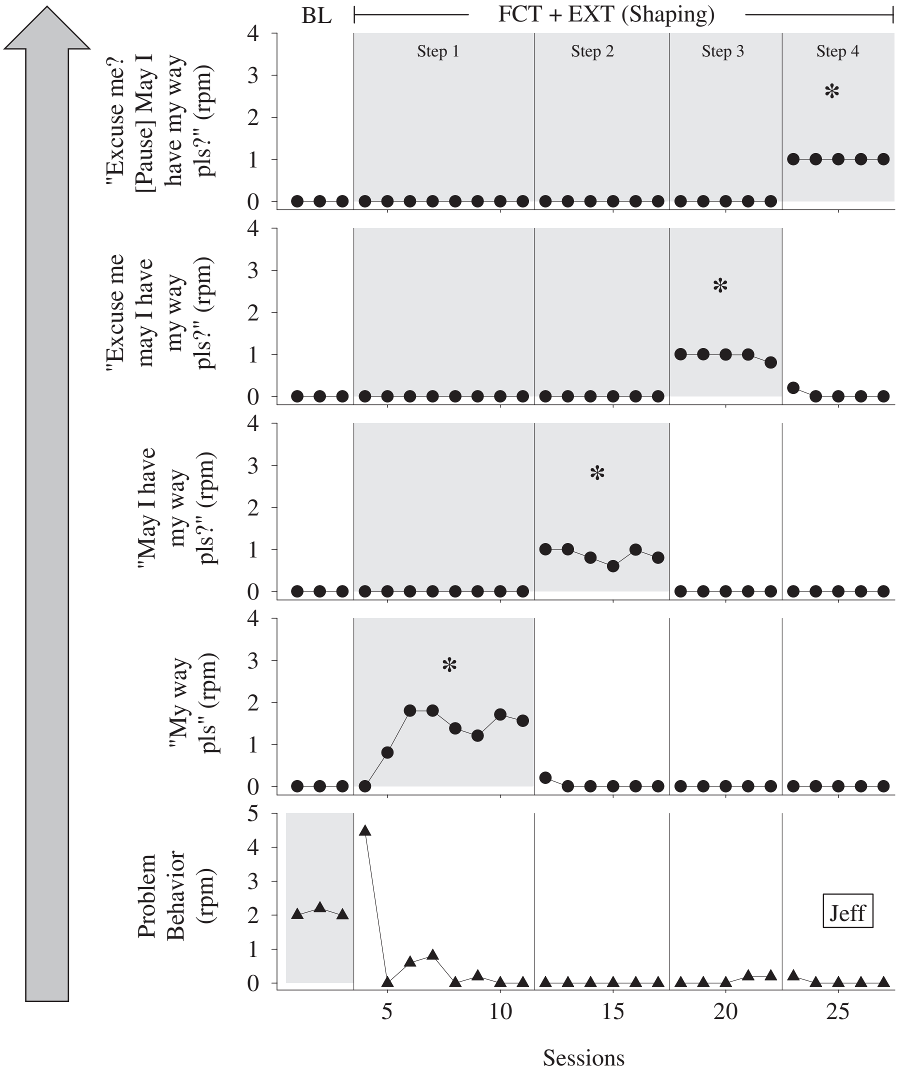

Figure 3. Results of the shaping procedure during FCT for Jeff. Panels are to be read from bottom to top as indicated by the arrow to the left. The asterisks indicate the FCR topography targeted during each shaping phase, although only independent responses are depicted in each panel. The grey shaded area depicts the topographies that are reinforced during that phase.

Method

Participants and setting. Two children referred to our university-based outpatient clinic for assessment and treatment of severe problem behavior participated in Experiment 2. Luke was a 5-year-old boy with a diagnosis of autism and ADHD who engaged in daily episodes of highly disruptive tantrums that involved vocal and physical disruptions and aggression including throwing furniture at others. Luke had age-appropriate language and play skills and could follow multistep vocal instructions. Milly was a 10-year-old girl with a diagnosis of autism who engaged in daily episodes of severe tantrums that included self-injury and aggression. These episodes had negatively impacted

Milly's and her family's quality of life and had resulted in her exclusion from leisure activities and community outings. Milly's problem behaviors had also resulted in the temporary termination of her home-based therapy sessions, exclusion from school activities, and frequent early dismissal from school. Milly was mostly nonvocal, but occasionally communicated using a few two-word phrases. She could follow simple vocal instructions and had a limited play repertoire (i.e., repetitive stimulatory engagement).

Sessions for both participants were 5 min during functional analyses and FCT and were conducted in the same room and in the same manner as described in Experiment 1.

Measurement and interobserver agreement (IOA). Response measures were similar to those from Experiment 1. Problem behavior for Luke and Milly included *aggression* (hitting and kicking) and *disruptions* (physical disruptions such as flopping, throwing, ripping, swiping and pushing items, and vocal disruptions such as yelling, growling, hissing, or loud high-pitched screams). Problem behavior for Milly also included *self-injury* (chin grinding and arm biting). Tables 1 and 2 summarize the FCR topographies and the manner of the presentation of the evocative context at each step for Luke and Milly, respectively. FCRs were considered prompted if the analyst prompted any aspect of the FCR within 10 s of the child's FCR. Only independent FCRs are reported.

IOA was assessed using the same methods as Experiment 1. IOA for problem behavior and FCRs averaged 99% (range, 87%-100%) and 99.5% (range, 92%-100%) during the functional analysis and 99% (range, 77%-100%) and 97% (range, 77%-100%) during the treatment analysis, for Luke and Milly, respectively.

Functional assessment process. The assessment procedures were identical to Experiment 1. The results of the open-ended interview with Luke's mother and grandmother suggested a synthesized contingency of positive and negative social reinforcement for Luke's problem behavior. Luke's mother and grandmother noted that he engaged in problem behavior when his preferred activities were interrupted and demands to engage in a different task or to engage differently with the same task were placed. He also engaged in problem behavior when an adult did not comply with his requests or when an adult or peer engaged in a nonpreferred activity in his presence. Therefore, for Luke's problem behavior, we tested a synthesized contingency involving the simultaneous delivery of escape from adult instructions, resumption of his activity, and access to attention including compliance with mands.

During the control condition, Luke was given uninterrupted access to his preferred activities and the analyst's undivided attention without the presentation of any demands, while all his reasonable requests were honored. During the test condition, the analyst interrupted Luke's play, delivered demands via three-step prompting, and ignored his requests. Contingent on any instance of problem behavior, the analyst allowed Luke to resume his activity in the manner that he preferred, removed all demands, and attended to his activity while honoring all of his requests for 30 s.

The results of the open-ended interview with Milly's mother suggested a synthesized contingency of tangibles and attention for Milly's problem behavior. Milly's mother noted that she engaged in problem behavior when her preferred activities were interrupted, when she was asked to engage with less preferred leisure activities or independent tasks, when an item (e.g., tablet, dolls) or adult attention was not available, and when others did not comply with her requests. Further discussions with Milly's mother made it clear that Milly often complied with specific demands when presented in a one-on-one context that included the undivided attention of an adult (e.g., discrete trial training). Rather, the most problematic context for Milly was one in which her preferred activities

Table 2
Criteria for Each Functional Communication Response (FCR) Topography and Manner of Presentation of the Evocative Context for Milly

Steps	FCR Criterion for Reinforcement	Evocative Context Presentation
1	A vocal mand in a sentence fragment; no calm voice requirement *"My way please"*	Interrupted ongoing activity by touching preferred items but did not remove items. Simultaneously presented a vocal demand to stop activity, stopped granting child's requests, and withheld attention.
2	A vocal mand in an autoclitic frame with a calm voice *"May I have my way please?"*	Interrupted ongoing activity by touching preferred items but did not remove items. Simultaneously presented a vocal demand to stop activity, stopped granting child's requests, and withheld attention.
3	A vocal mand in a sentence fragment; with a calm voice and hands down *"My way please"*	Interrupted ongoing activity and removed preferred items. Simultaneously presented a vocal demand to stop activity, stopped granting child's requests, and withheld attention.
4	A vocal mand in an autoclitic frame with a calm voice and hands down *"May I have my way please?"*	Interrupted ongoing activity and removed preferred items. Simultaneously presented a vocal demand to stop activity, stopped granting child's requests, and withheld attention.
5	A vocal mand in an autoclitic frame with a calm voice and with an attention-seeking response requiring some eye-contact with the listener *"Excuse me may I have my way please?"*	Interrupted ongoing activity and removed preferred items. Simultaneously presented a vocal demand to stop activity, stopped granting child's requests, and withheld attention.
6	A two-part vocal mand in an autoclitic frame with a calm voice and with an attention-seeking response requiring some eye-contact with the listener while pausing for acknowledgement from the listener before emitting the second part of the mand *"Excuse me?"[pause to receive acknowledgement] "May I have my way please?"*	Interrupted ongoing activity and removed preferred items while looking away from the child. Simultaneously presented a vocal demand to stop activity, stopped granting child's requests, and withheld attention.

were restricted and she was told to independently engage in other nonpreferred activities that were freely available without attention and direction from the adult (e.g., leisure activities such as puzzles or books, independent academic worksheets). Therefore, a synthesized contingency involving the simultaneous delivery of access to uninterrupted preferred activities and continuous attention including compliance with mands was tested for Milly.

During the control condition, Milly was given uninterrupted access to her preferred activities (e.g., iPad, dolls, playdoh, soft toys) and the analyst's undivided attention without the presentation of any demands while all her reasonable requests were honored. During the test condition, the analyst interrupted Milly's play, directed her to an array of nonpreferred activities (e.g., puzzles, books, worksheets) she could engage in, and ignored all her requests and bids for attention. Contingent on any instance of problem behavior, the analyst returned Milly's preferred items and allowed her to resume her activity in the manner that she preferred while responding to all her bids for attention and honoring her requests for 30 s.

Treatment process. Baseline sessions were identical to the test sessions from the IISCA, for both participants. The complexity and difficulty of the FCR and the evocative context were increased in four steps for Luke and in six steps for Milly along the dimensions noted in Tables 1 and 2, respectively, and within a changing criterion design. During the shaping process, most-to-least prompting starting with immediate full-vocal and textual (Milly only) prompts was used within the session to teach the target FCR. Prompts included specification, modeling, and full or partial physical prompting of the various dimensions of the response (e.g., calm voice, hands-down) as necessary. Reinforcers were withheld and prompts were repeated as necessary until the child responded to the prompt. When 80% of FCRs were independent in one session, full vocal prompts were provided every 60 to 90 s, if needed (this rarely occurred). All procedural details remained the same as Experiment 1, except for the additional steps described below.

Terminal topography (TT) probes were conducted to assess the necessity of the shaping procedure. The TT FCR requirements and the evocative context presentation during these probe sessions were identical to Step 4 for Luke and Step 6 for Milly. Prior to the first TT probe session in each phase, the analyst specified the reinforcement contingency through verbal instruction and engaged in one practice trial followed by the immediate reinforcement of the prompted response. During the probe sessions, only independent or prompted FCRs that met the TT requirements (i.e., Step 4 for Luke and Step 6 for Milly) were reinforced, and problem behavior and all prior, simpler topographies of FCR were placed on extinction. A full vocal prompt was provided every 60 to 90 s (i.e., no shaping of the response was conducted within the probe sessions). If the correct FCR was not emitted, the EO was continued (e.g., tangibles were withheld, demands were continued and three-step prompting was implemented) for another 60 to 90 s or until the session ended. The reinforcement interval during these probes was increased to 60 s for both participants.

Luke was taught the initial topography of the FCR (Step 1) as part of a separate study evaluating the effects of initial prompting strategies during FCT. Once the initial FCR was acquired, we evaluated the necessity of the gradual shaping procedure for increasing the complexity of this response at each subsequent step. The reinforcement interval during all subsequent phases (Step 2 onwards) was increased to 60 s. For Milly, TT probes were conducted prior to the introduction of Step 1 as well as at each subsequent step. The reinforcement interval during Steps 5 and 6 was increased to 60 s. For both participants, each step was considered mastered following four consecutive sessions of stable responding, at which point the TT probes were repeated before introducing the next step.

Results and Discussion

Luke's problem behavior was observed exclusively in the test sessions in which it terminated adult demands and yielded access to tangibles, attention, and compliance with requests (Figure 4). Milly's problem behavior was sensitive to a context that included a synthesis of only social positive reinforcers, as problem behavior was observed exclusively in the test sessions in which problem behavior allowed her to regain access to her highly preferred items, adult attention, and compliance with her requests (Figure 4).

Similar to Experiment 1, during FCT, an optimal level of independent FCRs was

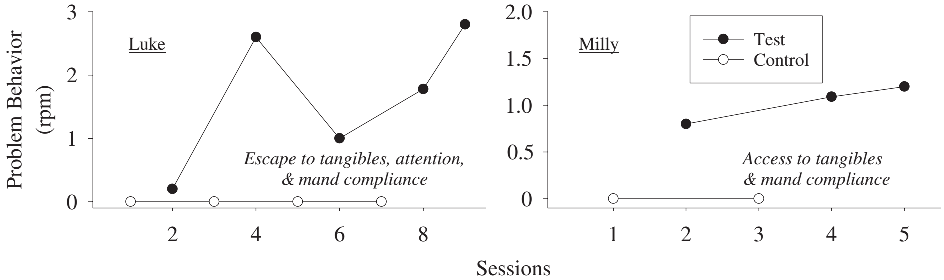

Figure 4. IISCA results for Luke and Milly.

approximately two instances per minute when the reinforcement interval was 30 s (Step 1), and one response per minute when the reinforcement interval was increased to 60 s (Step 2 onwards). Although prompted FCRs are not depicted here, the provision of prompts can be gleaned from the lower-than-optimal rate of independent FCRs (e.g., session 20 for Milly).

At Step 1, Luke engaged in near-zero rates of problem behavior and optimal rates of FCRs with FCT at the first criterion (Figure 5). The implementation of the Step 4 criterion during the TT probes resulted in an immediate increase in problem behavior above baseline levels, loss of the Step 1 FCRs, and near-zero rates of Step 4 FCRs, across the three probe sessions. When the second criterion was introduced, near-zero rates of problem behavior were immediately obtained, Step 1 FCRs were quickly eliminated, and Step 2 FCRs increased to optimal levels. A second TT probe was conducted following four sessions of stable responding at Step 2. Once again, the introduction of Step 4 criteria resulted in an immediate, sharp increase in problem behavior above that of baseline, the immediate loss of Step 2 FCRs, and low levels of Step 4 FCRs. Step 3 was then introduced, resulting in optimal rate of Step 3 FCRs and near-zero rates of problem behavior. Following four sessions of stability, a third TT probe was conducted. Although Step 4 FCRs were emitted during these probes, problem behavior once again increased above baseline levels. Step 4 was then introduced using the shaping procedure, which included within session, most-to-least prompting, resulting in an immediate reduction in problem behavior to near-zero levels and a gradual increase of Step 4 FCRs to optimal levels.

For Milly, there was an immediate and sustained increase in problem behavior above baseline levels paired with a resurgence of lower-level FCRs with the implementation of the Step 6 criterion during the initial and all subsequent TT probes (Figure 6). When Step 1 criterion was introduced using the shaping procedures, however, problem behavior was immediately eliminated as Step 1 FCRs were acquired and emitted at the optimal level. Step 3 was introduced next. Although Step 3 FCRs were initially acquired and emitted at an optimal rate, there was a slight resurgence of problem behavior and a subsequent loss of target FCRs. Given the topography of problem behavior (grabbing) that resurged, an intermediate step (Step 2) was added between Steps 1 and 3 that included a “hands down” (defined as keeping her hand on or near her lap) component. With the introduction of Step 2, problem behavior was decreased but Milly’s FCRs increased above the criterion level to Step 4 FCRs. Step 4 FCRs were, therefore, mastered without direct teaching. Once responding was stable for four sessions, Step 5 was introduced following a TT probe. Responding, then, closely conformed to each subsequent criterion in that the target FCRs occurred at optimal rates, while problem behavior and prior FCRs occurred at or near zero. Finally, Step 6 FCRs (i.e., TT FCRs) were acquired and emitted at an optimal rate only when Step 6 shaping procedures were introduced.

The efficacy of the shaping procedure for increasing the complexity of the FCR without much problem behavior was demonstrated within a changing criterion design for both children. Across 11 criteria, responding conformed to the target criterion (or above) in 10 out of 11 instances. In addition, there was an immediate and sharp increase in problem behavior during the TT probes, and by contrast, low levels of problem behavior during the shaping process, confirming the relevance of the shaping procedure.

GENERAL DISCUSSION

Once problem behavior was eliminated and replaced with a low-effort and highly efficient FCR, more complex FCRs were shaped by gradually expanding the contingency class of

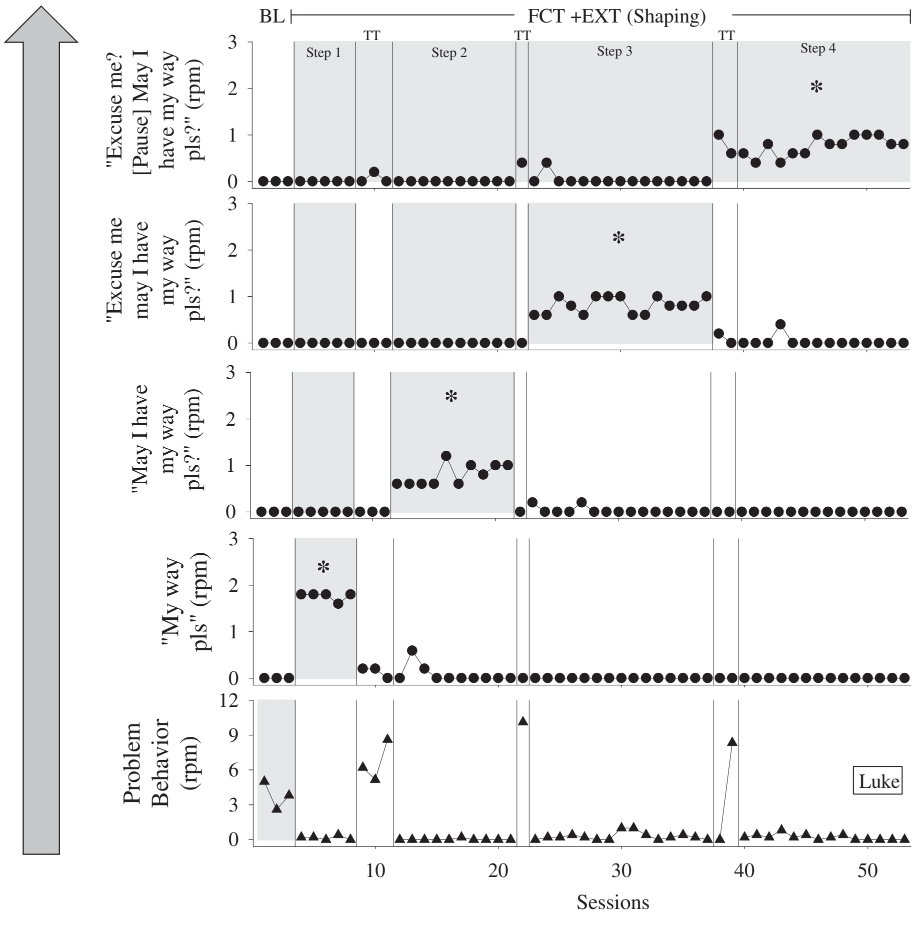

Figure 5. Results of the shaping procedure during FCT for Luke. Panels are to be read from bottom to top as indicated by the arrow to the left. TT refers to terminal topography probes of the complex FCR of "Excuse me? [pause] May I have my way please?" The asterisks indicate the FCR topography targeted during each shaping phase, although only independent responses are depicted in each panel. The grey shaded area depicts the topographies that are reinforced during that phase.

responses that were placed on extinction to include both problem behavior and simpler forms of the FCR and by slowly increasing the level of EO exposure. The shaping procedure was found to be efficacious for minimizing problem behavior while a complex functional communication response was acquired by all participants. The effects were systematically replicated across four participants with autism or ADHD and with varying degrees of age-appropriate language and instruction-following skills. This gradual shaping procedure for increasing the complexity of the FCR also resulted in fewer instances of problem behavior as compared to the two-step procedure modeled by Hanley et al. (2014) and Santiago et al. (2016). The percentage of sessions without problem behavior during the complex FCR training was 89% for Jian and 81% for Jeff, compared to only 33% for Dale and 50% for Bob from Hanley et al., and 47% for Zeke and 70% for Karen from Santiago et al. The shaping procedure was also demonstrated to be necessary for strengthening a complex communication

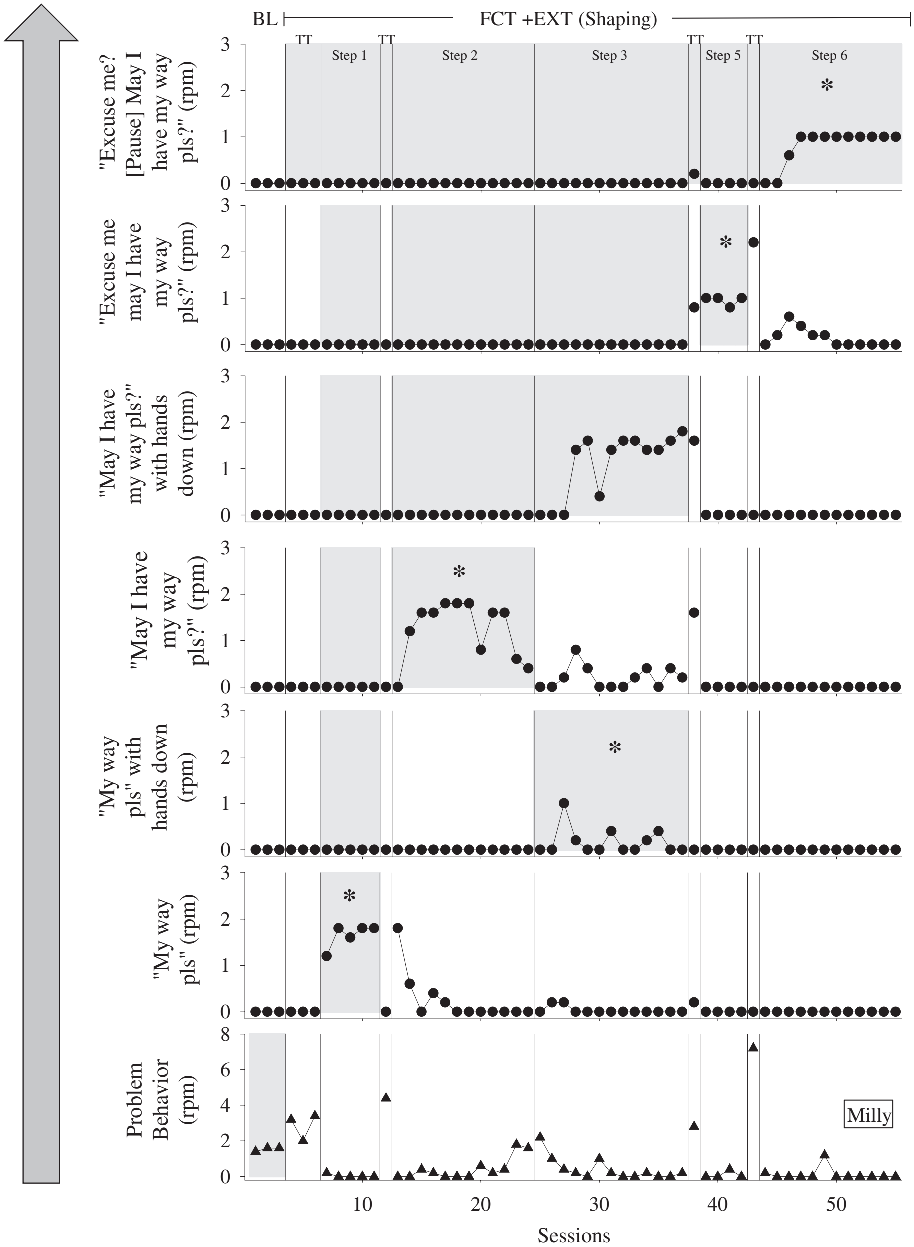

Figure 6. Results of the shaping procedure during FCT for Milly. Panels are to be read from bottom to top as indicated by the arrow to the left. TT refers to terminal topography probes of the complex FCR of "Excuse me? [pause] May I have my way please?" The asterisks indicate the FCR topography targeted during each shaping phase, although only independent responses are depicted in each panel. The grey shaded area depicts the topographies that are reinforced in that phase.

response while minimizing problem behavior for the two participants for whom the necessity of the procedure was evaluated (Luke and Milly).

In this study, we provided a model for demonstrating the effects of a shaping procedure in a changing criterion design, adding to the applied literature on the use of shaping as an efficacious teaching method (see also Bourret, Vollmer, & Rapp, 2004; Harrison & Pyles, 2013; Osbourne & Himadi, 1990). From a practical perspective, the shaping procedure was easily adjustable based on the different ways individual participants responded to each step. A return to the previous level (Jian) or the addition of intermediate steps (Milly), when necessary, quickly resulted in reduction of problem behavior and eventually led to acquisition of the complex FCRs. In addition, when a more complex topography of the FCR was acquired (Milly), the intermediate steps were eliminated to increase the efficiency of the treatment. Overall, responding conformed to the target criterion (or above) in 21 out of 23 instances across four participants with varying degrees of language and instruction-following abilities. The change in performance, however, was not always gradual. The provision of contingency-specifying instruction prior to the introduction of each criterion, and the inclusion of within-session most-to-least prompting may have influenced the outcomes as well.

In addition to prompting and gradually reinforcing successively closer approximations of the terminal FCR, the shaping procedure in this study also included a gradual introduction of the amount and type (strength) of the EO as well as an increased duration of reinforcement for the more complex FCRs. These additional components were included to minimize problem behavior from occurring during the process and to further increase the efficiency of the complex FCR, as this response would result in a more immediate and longer duration of reinforcement than problem behavior (Athens & Vollmer, 2010; Derosa et al., 2015). The increased duration of reinforcement alone, however, was not sufficient to counter the effects of response effort and the longer duration of EO exposure. High rates of problem behavior were observed during TT probes in Experiment 2, despite the longer duration of reinforcement for the more complex FCR. The extent to which the gradual introduction of EO is an essential component of this shaping procedure, however, remains to be evaluated. Future researchers should further evaluate the role of EO exposure (duration and type) during the initial stages of treatment as well as during the shaping of more complex FCRs. Terminal topography (TT) probes were also an efficient method for demonstrating the necessity for shaping. When applied with the two participants in Experiment 2, it was evident that in the absence of within-session most-to-least prompting and gradual changes to the reinforcement contingency, problem behavior was evoked and the more complex FCRs were rarely emitted. These probes also resulted in an immediate and sharp increase in problem behavior above baseline levels. By contrast, near-zero levels of problem behavior were maintained during the shaping process for the participants with whom TT probes were not employed. Given these results, and the results of a number of other studies that have shown high-effort responses do not effectively compete with problem behavior (e.g., Buckley & Newchok, 2005; Horner & Day, 1991; Richman et al., 2001; Ringdahl et al., 2009), it may be safest to assume that gradually shaping closer approximations to the final complex response is optimal. In other words, repeatedly conducting TT probes in relevant settings may not be necessary. This may be particularly important for individuals with a long history of severe problem behavior and in settings in which managing elevated rates of problem behavior is not possible. If time is limited, however, and some emission of the problem behavior is tolerable, quick probes of higher level responses may be useful to determine the extent to which some intermediate steps may be eliminated.

Although FCT has been shown to be highly effective at reducing problem behavior, the majority of researchers have relied on simple communication responses throughout treatment. Given the demonstrated ineffectiveness of high effort responses during the initial phases of FCT (e.g., Buckley & Newchok, 2005; Horner & Day, 1991; Richman et al., 2001), this reliance on simple FCRs is not surprising. As demonstrated in this study, however, it is possible to shape more complex FCRs, as recommended by Tiger et al. (2008), without negatively impacting treatment effectiveness. Beginning treatment with a novel but simple FCR and shaping it into a more socially adept response may be the optimal strategy for maximizing the efficiency, generality, and social acceptability of FCT. In other words, rather than rely on either simple or more complex FCRs, the solution may be to rely on both, in order, and with some intermediate forms during a shaping process. The simple FCR is probably critical for quickly eliminating problem behavior. The complex and developmentally appropriate communication responses may be more acceptable and thus acknowledged by adults and peers in environments typically experienced by the individual (Durand and Carr, 1992), further increasing the social validity and overall effectiveness of FCT. Complex FCRs that include an autoclitic frame may also lead to better generalization and emergence of novel mands (Hernandez et al., 2007). These hypotheses, however, are worthy of additional attention by researchers.

The complexity of the communications response was increased by adding an autoclitic frame, requiring eye-contract, appropriate tone, an attention seeking response, and an acknowledgement response. The selection of these particular components was not arbitrary; however, the importance of each element remains to be evaluated. In this study, we merely described a means by which practitioners and researchers can shape more complex FCRs safely and without negative side effects; the type of elements that comprise a complex response can probably be altered to meet other cultural and situational demands. In other words, the specific dimensions of the communication response that are targeted for improvement, and the manner in which the overall complexity and appropriateness of the communication response is increased can vary. For instance, perhaps a longer chain of responses, better fluency, enhanced social pragmatics, or more mand specificity may be desirable. In addition, the use of an omnibus mand, a mand yielding several reinforcers following a synthesized contingency analysis, may ultimately be too general for some participants and their caregivers. Future researchers should evaluate the use of a similar shaping procedure for increasing the complexity and specificity of FCRs.

We did not determine the extent to which there was a main effect of each isolated reinforcement contingency or an interaction between these contingencies. The precise role of each variable in the synthesized contingencies for maintaining problem behavior was never evaluated in isolation. Instead, each IISCA emulated the typical conditions experienced by the child, in which various positive and negative social consequences operated simultaneously to create a context that exerted control over the child's problem behavior. The isolation of variables was neither desirable nor possible in many instances. The nature of the experiences that evoked each child's problem behavior involved a simultaneous provision of EOs typically associated with both negative and positive reinforcement or with different forms of positive reinforcement. For example, removing interruptions of Luke's play meant that Luke simultaneously *escaped* adult-led interactions and resumed his uninterrupted *access* to his preferred activity. Providing Milly with complete access to her most preferred activity, the iPad, necessitated the availability of an adult's attention to help her navigate the device if required. Attempts to isolate these variables may unnecessarily decouple a naturally occurring interaction that may be necessary to evoke problem behavior (see for example, Bowman, Fisher, Thompson, & Piazza, 1997; Hagopian, Bruzek, Bowman, & Jennet, 2007; Hanley et al., 2014; Slaton, Hanley, & Raftery, 2017).

Our experience that the distinction between positive and negative reinforcement seems arbitrary and difficult to disentangle in many of these examples is not unique to the participants of this study. Others have also highlighted the difficulty of making such distinctions and have questioned the necessity and practical usefulness of doing so (Baron & Galizio, 2005; Michael, 1975). Baron and Galizio, for example, argued that in many cases the addition of one stimulus condition involves the simultaneous removal of another, leaving the interpretation open to implicating either positive or negative reinforcement depending on which condition we focus on. Engagement in an activity often precludes one's engagement in another; in other words, "access" often includes simultaneous "escape." Conversely, negative reinforcement often involves not just "escape from" an activity but also "escape to" another activity. The aversiveness of an event evoking escape may be mediated by the reinforcing value of the activity that one can "escape to." These issues make it difficult to draw any conclusions about the main effects of any reinforcement contingency, whether isolated or synthesized.

What is perhaps more important is the inclusion of all possible reinforcers within the contingency to create a sufficiently challenging and reliable context in which to develop functional communication. In all four cases, our assessment process enabled us to identify such a context. In addition, rather than relying on general categories of reinforcement (i.e., escape, attention, tangible, automatic), we found it helpful to identify the idiosyncratic and qualitatively rich details of the type of activities and manner of presentation of stimulus conditions that evoke problem behavior. Although categorizing the synthesized contingencies using the traditional terms implies identical reinforcement contingencies for three of the four children, there were many qualitative differences identified through the assessment process that may be key to the effective treatment of problem behavior. The relative advantages and disadvantages of using more or less qualitatively rich reinforcement contingencies remains to be evaluated, however.

Finally, in addition to the recommendation by Tiger et al. (2008) to shape more complex communication responses, the inclusion of procedures to maintain FCRs and minimize problem behavior when reinforcement is unavailable is also paramount (Durand & Moskowitz, 2015; Ghaemmaghami, Hanley, & Jessel, 2016; Hagopian, Boelter, & Jarmolowicz, 2011; Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998; Kurtz, Boelter, Jarmolowicz, Chin, & Hagopian 2011; Rooker, Jessel, Kurtz, & Hagopian, 2013; Tiger et al., 2008). The order in which these recommendations should be implemented is a question for future research. Increasing the complexity of the FCR by adding multiple components such as attention-seeking and acknowledgement responses will result in a slight delay to reinforcement as the individual completes this chain. This may in turn result in the acquisition of an initial toleration repertoire for periods of nonreinforcement (Ghaemmaghami et al., 2016). On the other hand, directly teaching the individual to tolerate delays to reinforcement following the acquisition of a simple FCR, may expedite the acquisition of more complex FCRs. Issues of order are difficult to disentangle, but given the prevalence of problem behavior (Brauner & Stephens, 2006; Murphy, Healy & Leader, 2009) and the popularity of FCT as intervention (Durand & Moskowitz, 2015; Tiger et al.), future research should seek to determine the relative strengths and disadvantages of each approach.

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