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AN EVALUATION OF TIME IN ESTABLISHING OPERATION ON THE EFFECTIVENESS OF FUNCTIONAL COMMUNICATION TRAINING

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Abstract

We examined whether different durations of exposure to relevant establishing operations (EO) during treatment of problem behavior affected treatment efficacy and response bursting. In Study 1, we compared 2 functional communication training (FCT) interventions. In the first treatment, we used a card touch as the target mand; this was associated with limited exposure to the EO because we could physically guide the mand at prescribed times. In the other treatment, we used a vocal response as the mand; this was associated with longer exposure to the EO because it was not possible to guide the response. In Study 2, we exposed participants to time-based reinforcement schedules that were yoked to the schedules of obtained reinforcement from the 2 FCT interventions in Study 1. Results indicated that limited exposure to the EO was associated with less response bursting, larger and more rapid reductions in problem behavior, and faster acquisition of the alternative mand.

Keywords

establishing operations; extinction; differential reinforcement; functional communication training

Differential reinforcement of alternative behavior (DRA), when coupled with extinction, is an effective approach in the treatment of severe problem behavior. Functional communication training (FCT; Carr & Durand, 1985) is a well-established and effective DRA procedure used to teach children socially appropriate and functionally equivalent alternative mands to replace problem behavior (see Tiger, Hanley, & Bruzek, 2008, for a review). When best practices are used, FCT involves three general components: (a)

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implementation of a functional analysis to determine the maintaining variables for problem behavior, (b) training of a functionally equivalent alternative mand, and (c) the maintenance and generalization of the alternative response (Fisher & Boussein, 2011; Tiger et al., 2008). FCT is most often used for problem behavior reinforced by social consequences (e.g., attention, escape, tangible items; Betz, Fisher, Roane, Mintz, & Owen, 2013).

As previously mentioned, the combination of FCT and extinction is an effective procedure for the reduction of problem behavior. In fact, studies have indicated that FCT implemented in the absence of extinction most often did not lead to sufficient reductions in target problem behavior (Hagopian, Fisher, Sullivan, Aquisto, & LeBlanc, 1998). Clinically significant reductions in the occurrence of problem behavior (and, conversely, the emergence of a communication response) may not have occurred in these studies during FCT in the absence of extinction for several reasons. For instance, it may have been that, relative to problem behavior, the communication response was associated with greater response effort, or was not sufficiently strengthened due to a lack of pairing with reinforcement. Functional communication training may have been enhanced with procedural variations or the addition of punishment, but several authors have identified the effectiveness of FCT with the addition of extinction only (see Hagopian et al., 1998). Therefore, it is reasonable to begin implementation of FCT with extinction in place and later progress to the use of more restrictive procedures (i.e., punishment) or alter the procedures (i.e., response blocking; within-session prompting for communication) if problem behavior is not sufficiently reduced (Tiger et al., 2008).

Researchers have demonstrated the effective use of several different mand topographies during FCT, including card touches or exchanges (e.g., Lalli, Casey, & Kates, 1997), vocal responses (e.g., Marcus & Vollmer, 1995), manual signs or gestures (e.g., Derby et al., 1997), and microswitch activations (e.g., Steege et al., 1990; Wacker et al., 1990). Unfortunately, few empirically validated procedures are available for choosing an appropriate mand topography, and it is therefore often an arbitrary selection process (see Ringdahl et al., 2009, for an exception). However, several studies have examined the variables related to mand topography that most likely influence the effectiveness of FCT.

Several studies (e.g., Bailey, McComas, Benavides, & Lovasz, 2002; Buckley & Newchok, 2005; Horner & Day, 1991; Richman, Wacker, & Winborn, 2001) have examined the influence of response effort and reinforcement schedules on FCT outcomes using single- and concurrent-operants arrangements as well as response chains. Overall, results across studies generally indicated that (a) low-effort mands decreased problem behavior more than high-effort mands, (b) dense schedules of reinforcement for mands reduced problem behavior more than lean schedules, and (c) immediate reinforcement for mands decreased problem behavior more than delayed reinforcement. Studies have also shown that an individual's history with a mand topography can affect FCT outcomes. Winborn, Wacker, Richman, Asmus, and Geier (2002) demonstrated that mands that existed in an individual's repertoire before treatment were more likely to be used during FCT than novel mands taught at the outset of treatment. However, problem behavior was also noted to be higher when existing mands were used. Ringdahl et al. (2009) demonstrated that proficiency with responding was an additional variable that affected the effectiveness of FCT. In addition, Durand (1999)

demonstrated that some mand topographies were more likely to be supported by natural contingencies than others, which is important when maintenance and generalization of the response are considered. Results of the aforementioned studies indicated the relevance of several different variables on FCT outcomes. Further examination of FCT procedures may assist in the identification of additional variables that influence the efficiency and effectiveness of this reinforcement-based intervention.

A time-based schedule (TBS) of reinforcer delivery (often referred to as *noncontingent reinforcement*) represents another reinforcement-based procedure that, when used in conjunction with extinction, is effective at reducing the occurrence of problem behavior (Fisher, DeLeon, Rodriguez-Catter, & Keeney, 2004; Lerman & Iwata, 1995). TBSs involve the response-independent delivery of the reinforcer that is responsible for maintaining the target response (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993). Typically, when a TBS is first introduced, the functional reinforcer is delivered on a dense (sometimes continuous) schedule, which may account for the attenuation of extinction-induced problem behavior. However, one limitation of TBSs is that they do not promote the acquisition of appropriate alternative behavior.

Fisher et al. (2004) have shown that dense TBSs are more effective in reducing the occurrence of problem behavior than lean TBSs. Further, these authors have demonstrated that dense TBSs can enhance the effects of extinction and prevent response bursting (Fisher et al., 2004; Hagopian, Fisher, & Legacy, 1994). One rationale for the differential effectiveness of the schedules of reinforcement present during TBSs is the duration of exposure to the relevant establishing operation (EO). More specifically, dense TBSs provide frequent access to the reinforcer, resulting in less exposure to the relevant EO. Conversely, lean schedules of reinforcement are associated with longer interreinforcement intervals, which in turn result in increased exposure to the relevant EO.

Given the findings of TBS evaluations related to dense versus lean schedules of reinforcement and the occurrence of problem behavior, duration of exposure to the relevant EO may similarly affect FCT outcomes. For example, mands that involve higher levels of response effort may result in longer exposures to the EO relevant to problem behavior because higher effort mands typically take longer to emit than lower effort mands, higher effort mands may be emitted less frequently than lower effort mands, or both. Similarly, leaner schedules of reinforcement for the mand necessarily result in less frequent reinforcement, which results in increased exposure to the EO relevant to problem behavior (compared to denser schedules). Finally, delayed reinforcement of the mand exposes the individual to the EO relevant to problem behavior during each delay, whereas immediate reinforcement does not; thus, the longer the delay, the longer the duration of exposure to the relevant EO.

It is quite possible that exposure to the EO relevant to problem behavior during FCT operates in a manner similar to what occurs in TBSs. That is, sudden drops in the density of reinforcement during TBSs produce inverse increases in duration of exposure to the EO relevant to problem behavior, which can produce response bursting and even evoke aggression or other problem behavior (e.g., Cherek & Pickens, 1970; Ferster & Skinner,

1957). It is therefore reasonable to hypothesize that sudden drops in the density of obtained reinforcement during FCT (due to increased response effort or leaner or more delayed reinforcement schedules) would similarly evoke increases in problem behavior or produce response bursting.

Based on this rationale, in the current study we examined the influence of different durations of exposure to the EO relevant to problem behavior on the effectiveness of FCT outcomes in terms of (a) reductions in problem behavior, (b) acquisition of the alternative mand, and (c) the emergence of response bursting. In Study 1, we compared two FCT interventions. In one treatment, we used a card touch as the mand (FCT card) because we could physically guide the mand to occur at prescribed times, thus ensuring limited exposure to the relevant EO. In the other treatment, we used a vocal response as the mand (FCT vocal), with which we could not ensure limited exposure to the relevant EO because it is not possible to physically guide a vocal response. We hypothesized that FCT card would be associated with limited exposure to the EO relevant to problem behavior given the use of physical guidance and therefore would result in larger and more rapid reductions in problem behavior, more rapid acquisition of the mand, and less frequent emergence of bursting (relative to the FCT-vocal condition).

However, Study 1 left open the possibility that observed differences in problem behavior were due to other extraneous differences between the FCT-card and FCT-vocal conditions (i.e., response-related variables). Therefore, in Study 2 we exposed a single participant to two TBS interventions that were yoked to the schedules of obtained reinforcement observed during the two FCT interventions in Study 1. Study 2 included removal of response-related variables and provided a more direct test of whether the observed duration of exposure to the EO for problem behavior during Study 1 influenced the effectiveness of the interventions.

GENERAL METHOD

Participants and Setting

Two individuals (John and Frank) who had been referred to a program for the assessment and treatment of severe problem behavior participated in Study 1. Frank also participated in Study 2. Participants were recruited for this investigation if they (a) emitted problem behavior reinforced by social consequences according to the results of a functional analysis of problem behavior, (b) engaged in limited verbal vocal behavior (i.e., emitted a minimum of single-syllable sounds and maximum of limited three- or four-word requests), and (c) displayed a limited echoic repertoire (i.e., frequently emitted known phonemes or words immediately after they were modeled, but inconsistently emitted novel phonemes or words after they were modeled). The first two individuals who met the inclusion criteria were selected as participants. Information on participants' verbal vocal and echoic repertoires was gathered via parental report and direct observation of the individuals in the clinic.

John was a 4-year-old boy who had been diagnosed with autistic disorder and disruptive behavior disorder, not otherwise specified (NOS). Before treatment, John communicated primarily via single-word mands and occasional three- or four-word utterances. Frank was a 5-year-old boy who had been diagnosed with autistic disorder and impulse control disorder,

NOS. Before treatment, Frank primarily communicated via gestures and several single-word approximations (e.g., “heh” for head).

We conducted all sessions in therapy rooms (3 m by 3 m) that were equipped with one-way observation panels. Sessions lasted 5 min, and we conducted six to nine sessions per clinic visit for each participant. Materials in the room included a desk, two chairs, and other relevant session materials (i.e., demand materials, stimulus card).

Response Definitions and Measurement

Trained observers used laptop computers to collect second-by-second data on the frequency of problem behavior and the frequency of the target mands. Dependent measures included participants' aggression, disruption, independent mands, and prompted mands. *Aggression* was defined for both participants as forceful pushing or striking others with body parts (e.g., pushing, hitting, kicking, head butting), hitting others with objects, or biting. *Disruption*, for both participants, was defined as banging, throwing, overturning, tearing, or climbing on objects not made for that purpose, or repetitively turning equipment on and off (e.g., lights, television). Frank's disruptive behavior also included the following topographies: lifting up a therapist's article of clothing and exposing 1 in. or more of skin; untying or attempting to tie together the therapist's shoelaces; and tapping, grabbing, pulling, or attempting to manipulate an object held by the therapist.

An *independent mand* for both participants was defined as the participant requesting the reinforcer for problem behavior by touching a specific picture card (FCT card) or emitting a specific vocal mand (FCT vocal) in the absence of the delivery of a prompt from the therapist (i.e., no prompt for at least 5 s). A *prompted mand* was defined as the therapist physically guiding the participant to touch the picture card (FCT card) or the participant emitting the vocal mand within 5 s following the echoic prompt delivered by the therapist (FCT vocal).

Interobserver agreement was assessed by having a second observer collect data simultaneously but independently during 52% and 57% of the FCT analysis sessions in Study 1 for John and Frank, respectively. A second independent observer also collected data for the purpose of obtaining interobserver agreement scores during 77% of the TBS analysis sessions in Study 2 for Frank. Exact agreement coefficients for each dependent variable were calculated by partitioning the sessions into 10-s intervals, dividing the number of exact agreements by the number of agreements plus disagreements, and converting the resulting quotient to a percentage. An agreement was defined as two observers scoring the same number of occurrences of target behavior within the same 10-s interval. A disagreement was defined as the two observers not scoring the same number of occurrences of the target behavior.

The mean agreement for problem behavior during the FCT analysis conducted in Study 1 was 95% for John (range, 73% to 100%) and 92% for Frank (range, 70% to 100%). The mean agreement for the independent mand was 100% for both John and Frank. The mean agreement for the prompted mand was 99% for John (range, 56% to 100%) and 93% for

Frank (range, 67% to 100%). During the TBS analysis conducted with Frank in Study 2, mean agreement for problem behavior was 91% (range, 63% to 100%).

Preexperimental Procedure

Before implementation of the experimental procedures, preference assessments and functional analyses of problem behavior (with regular checks on interobserver agreement) were conducted as part of the participants' routine clinical treatment. (In the interest of brevity, those procedures and corresponding results are not described in detail here, but are available from the first author.) A paired-choice preference assessment was completed with John (Fisher et al., 1992), and a free-operant preference assessment was conducted with Frank (Roane, Vollmer, Ringdahl, & Marcus, 1998). Functional analyses were conducted with both participants to identify the environmental variables that maintained problem behavior using procedures similar to those of Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994; see Supporting Information).

STUDY 1

Method

Design—Components of both a multielement and a reversal design were used during the FCT analysis. The two interventions were compared to a baseline condition in a reversal design, and the two treatments were compared to each other using a multielement design in the second phase of the analysis.

Phase 1: Baseline: The baseline condition for each participant was identical to the condition of the functional analysis in which the highest rates of problem behavior were observed. The baseline condition for John was identical to the demand condition of the functional analysis. Frank's baseline condition was identical to the attention condition of the functional analysis.

During the demand condition, a therapist and John were present in the room with a desk, two chairs, and appropriate demand materials. Demands for John included gross motor (i.e., "touch your head") and object motor (i.e., "push the car") instructions. Three-step guided compliance (i.e., presentation of successive verbal, model, and physical prompts) was implemented contingent on noncompliance with instructions. Contingent on the occurrence of problem behavior, the therapist provided the statement "Okay, you don't have to" and discontinued delivery of demands for 20 s. There were no programmed consequences for other appropriate or inappropriate responses.

During the attention condition, a therapist and Frank were present in a room that contained a table and two chairs. A DVD player and movie (for the therapist's diverted attention) and one of Frank's low-preference toys (identified via the aforementioned preference assessment) were also present in the room. Before the start of a session, the therapist provided Frank with high-quality attention (i.e., singing children's songs and tickling) for 1 min. At the start of a session, the therapist informed Frank that she had to watch a movie but that Frank could play with the toy. The therapist then held the DVD player in her hands and assumed the appearance of watching the movie. Contingent on the occurrence of problem behavior, the therapist delivered attention in the form of verbal reprimands (i.e., "don't do

that,” or “I don’t like that”) for 20 s. There were no programmed consequences for other appropriate or inappropriate responses.

Phase 2: FCT treatment comparison: During this phase, a progressive prompt delay was used to teach each participant (a) to touch a picture card as the mand in the FCT-card condition and (b) to emit a vocal mand in the FCT-vocal condition. Based on the results of the functional analysis, John was taught to access a break from demands and Frank was taught to access social attention.

Each FCT session included 10 to 12 trials, each lasting approximately 30 s. Attention sessions for Frank were divided into 10 equal 30-s trials. Demand sessions for John were not divided into equal trials, but trials across sessions and FCT conditions ranged from 10 to 12. At the start of each trial, for John, the therapist said, “It’s time to do some work.” For Frank, she said, “I have to watch my movie now. You can play with your toy if you want to.” After this statement, the therapist waited the requisite amount of time based on the current progressive prompt-delay value (which started at 0 s and progressed to 2, 5, and then 10 s, with changes based on visual inspection of the data). If the participant emitted the target mand (either independently or prompted, i.e., within 5 s of the FCT prompt), reinforcement was delivered for the remainder of the 30-s interval (i.e., John was given a break from demands; Frank was given high-quality attention). If the progressive prompt-delay interval elapsed without the participant independently emitting the target mand (which always happened when the progressive prompt-delay value was 0), the therapist delivered the FCT prompt (i.e., she modeled the vocal mand in FCT vocal and physically guided the card touch in FCT card).

Because the FCT prompt in the FCT-card condition consisted of the therapist physically guiding the participant to touch the card, the prompt always resulted in the participant emitting the target response (i.e., a prompted mand). By contrast, in the FCT-vocal condition, the FCT prompt consisted of the therapist modeling the target mand, which did not always result in the participant emitting the target mand (i.e., the participant did not always imitate the modeled vocal mand). On trials in which the participant did not emit the target mand either independently or within 5 s of the FCT prompt, the EO relevant to problem behavior remained in effect for the remainder of the 30-s trial (John was prompted to complete a demand using sequential verbal, modeled, and physical prompts; the therapist ignored Frank and watched the video).

Phase 3: Return to baseline: This condition was identical to the baseline condition implemented in Phase 1 for each participant. Target vocal responses, if they occurred during this phase, were placed on extinction. Participants could not emit a card touch response during baseline because the card was not present during these sessions.

Phase 4: Replication of the more efficient FCT treatment: The more efficient treatment, based on more rapid reduction in problem behavior and acquisition of the target mand, for each participant during Phase 2 was reintroduced in Phase 4. FCT card was the more efficient treatment for both participants based on visual analysis of the data. Phase 4 ended when the FCT-card treatment reached the following two targets: (a) Problem behavior was at

least 85% lower than the previous baseline, and (b) the participant emitted the correct mand independently during at least 85% of the 30-s trials across three consecutive sessions.

Results and Discussion

Figure 1 (top) shows the rates of escape-maintained problem behavior during the demand baseline, FCT-vocal, and FCT-card conditions for John. During the initial baseline, John displayed relatively stable rates of problem behavior ($M = 1.6$ responses per minute; range, 0.9 to 2). During the second (multielement) phase, rates of problem behavior immediately dropped below baseline levels during the first three FCT-card sessions and then decreased further to near-zero levels for the remainder of the phase ($M = 0.2$ responses per minute; range, 0 to 0.6). During the first FCT-vocal session, an extinction burst was observed. There was a general downward trend in the rates of problem behavior during FCT-vocal sessions, which was interspersed with spikes in responding across sessions. Relative to FCT-card sessions, the mean rate of problem behavior was considerably higher in FCT-vocal sessions ($M = 1.6$ responses per minute; range, 0 to 5). During the return to baseline, John initially engaged in variable rates of problem behavior that stabilized at moderate rates towards the end of the phase ($M = 2$ responses per minute; range, 0 to 5). John initially engaged in low yet slightly variable rates of problem behavior during the final treatment phase (FCT-card condition). However, rates of problem behavior stabilized at zero during the final three sessions of the phase ($M = 0.24$; range, 0 to 0.6).

Figure 1 (middle) shows the percentage of independent (or unprompted) mands during the demand baseline, FCT-vocal, and FCT-card conditions for John. During the initial baseline, John did not emit the vocal mand and could not emit the card mand because the stimulus card used for the mand was not available during baseline. During the second (multielement) phase, percentages of the card-touch and vocal independent mands were both at zero (as expected) during the first six sessions when the progressive prompt delay was set at 0 s. However, once the progressive prompt delay was increased and John had an opportunity to respond independently, his independent card-touch responses immediately increased to between 90% and 100% for the remainder of the phase. By contrast, increases in the independent vocal responses proceeded more slowly and variably, reaching above 90% in just one FCT-vocal session. Overall, the mean percentage of independent mands during this phase (excluding sessions in which the progressive prompt delay was set at 0) was considerably higher in the FCT-card condition ($M = 98\%$; range, 91% to 100%) than in the FCT-vocal condition ($M = 46\%$; range, 0% to 93%) for John.

Figure 1 (bottom) shows the mean durations (depicted as percentage of session time) of exposure to the EO for problem behavior during the FCT-vocal and the FCT-card sessions for John. Exposure to the EO was high initially and then decreased during FCT-vocal sessions ($M = 64\%$ of session time) and was lower and relatively stable in FCT-card sessions ($M = 19\%$ of session time).

Figure 2 (top) shows the rates of attention-maintained problem behavior during the attention baseline, FCT-card, and FCT-vocal conditions for Frank. During the initial baseline Frank displayed variable, yet primarily elevated, rates of problem behavior ($M = 2$ responses per minute; range, 0 to 5.2). During the second (multielement) phase, rates of problem behavior

were initially variable across the first two FCT-card sessions, followed by a steady decrease to near-zero levels for the remainder of the phase ($M = 0.5$ responses per minute; range, 0 to 3.2). During FCT-vocal sessions, rates of problem behavior were highly variable and similar to baseline levels until the final three sessions of the phase ($M = 1.2$ responses per minute; range, 0 to 3.6). He again engaged in variable yet generally elevated rates of problem behavior during Phase 3, the return to baseline ($M = 1.3$ responses per minute; range, 0 to 4.6). During the final treatment phase, he engaged in zero to near-zero rates of problem behavior throughout the phase ($M = 0.02$ responses per minute; range, 0 to 0.2).

Figure 2 (middle) shows the percentages of independent (or unprompted) mands during the attention baseline, FCT-vocal, and FCT-card conditions for Frank. During Phase 1 and Phase 3 (baseline), Frank did not emit the vocal mand and could not emit the card-touch mand because the stimulus card was not available during baseline. Given that his initial baseline was lengthy, the progressive prompt delay was set at 0 s throughout the second (multielement) phase across both FCT conditions until stable levels of responding were clearly evident. Therefore, the percentages of the independent card touch and vocal mands were both at 0 during the FCT comparison phase. In the final phase, Frank displayed high levels of independent mands in the FCT-card condition when the progressive prompt delay was increased to 2 s ($M = 93\%$ of trials for the five sessions with a 2-s progressive prompt delay).

Figure 2 (bottom) shows the mean durations of exposure to the EO relevant to problem behavior during the FCT-card and the FCT-vocal sessions for Frank. It should be noted that data for Sessions 51 and 52 are missing due to an error with the data files after completion of the study. Exposure to the EO was relatively high and somewhat variable during FCT-vocal sessions ($M = 80\%$ of session time) and was lower and on a downward trend in FCT-card sessions ($M = 26\%$ of session time).

Results of Study 1 indicated that when the two FCT treatments were introduced, (a) the FCT-card treatment produced larger and more rapid reductions in problem behavior relative to the FCT-vocal intervention; (b) the FCT-card procedure produced faster acquisition of the mand; (c) the FCT-card procedure was implemented in four phases and never produced an extinction burst as defined by Lerman and Iwata (1995), whereas the FCT-vocal condition was used in two phases and an extinction burst occurred in one of those two phases (50%); and (d) duration of exposure to the EO for problem behavior was less for the FCT-card intervention than for the FCT-vocal intervention. We hypothesized that these differences occurred in part due to duration of exposure to the EO, which was limited in the FCT-card condition because we could quickly physically guide the target mand and was prolonged during the FCT-vocal condition because it is not possible to guide a vocal response physically. These findings were robust in that they were observed across behavioral functions (escape and attention).

One procedural detail that may have influenced the outcomes of John's FCT analysis was that specific instructions (e.g., "touch your head") were delivered in the FCT-vocal condition only in the absence of an independent or prompted mand. In addition, given that the two FCT treatments differed from one another in more ways than duration of exposure to the EO

relevant to problem behavior, results of Study 1 leave open the possibility that observed differences in problem behavior were due to one or more extraneous factors (e.g., response-related variables). Therefore, in Study 2 we conducted a more direct test of our EO hypothesis by removing response-related variables and exposing one participant to two TBSs that were yoked to the schedules of obtained reinforcement observed during the two FCT interventions in Study 1.

STUDY 2

Method

Design—After an initial baseline, the two TBSs were compared using a multielement design. The TBSs in Study 2 were yoked to the first 16 sessions from the FCT comparison phase of Study 1 for Frank. These FCT sessions were used to set the TBSs because they were the ones that involved differential levels of exposure to the EO for the FCT-card and FCT-vocal conditions.

Baseline: The baseline phase was identical to the baseline condition implemented with Frank in Phase 1 of Study 1 (e.g., attention condition), with the following change. To limit carryover effects from the prior treatment phases, the baseline phase was conducted in a novel treatment room with two novel therapists.

Time-based schedules (TBS) comparison: To facilitate discrimination across conditions, baseline levels of Frank's problem behavior with each therapist were used to assign the therapists to treatment conditions for the next phase. That is, the therapist associated with a higher mean rate of problem behavior during baseline was assigned to the TBS-card condition, and the other therapist was assigned to the TBS-vocal condition. This assignment was used because we predicted lower rates of problem behavior in the TBS-card condition. If our predicted outcome was observed, we did not want it to be potentially attributable to therapist effects.

During both TBSs, the previous target card response could not occur given that the stimulus card was not present, the previous target vocal response was on extinction, and the reinforcer that had previously maintained problem behavior was delivered on a response-independent TBS. There were no programmed procedures in place if problem behavior occurred contiguous with reinforcer delivery. During the TBS-card condition, exposure to the EO for problem behavior closely approximated the amount of exposure observed during the FCT-card condition in Study 1 by yoking the time-based reinforcer deliveries to the reinforcer deliveries recorded during the FCT-card condition in Study 1. Similarly, during the TBS-vocal condition, exposure to the EO for problem behavior closely approximated the amount of exposure observed during the FCT-vocal condition in Study 1 by yoking the time-based reinforcer deliveries to the reinforcer deliveries recorded during the FCT-vocal condition in Study 1. Sessions were counterbalanced across the TBS-card and TBS-vocal conditions such that the phase started with one condition followed by the other condition and no one condition occurred more than twice in a row. This phase ended after all 16 yoked sessions had been implemented.

Results and Discussion

Figure 3 shows results for Study 2. Overall, variable rates of problem behavior with a slightly increasing trend occurred during the baseline phase. Therapist 1 was associated with a higher average mean ($M = 4.4$ responses per minute; range, 0 to 7.8) and more variable rates of problem behavior during baseline than Therapist 2 ($M = 3.9$ responses per minute; range, 1.6 to 5.6). Therefore, Therapist 1 was assigned to the TBS-card condition, and Therapist 2 was assigned to the TBS-vocal condition.

During the second phase, when the two TBSs were introduced, problem behavior increased in the first TBS-vocal session (i.e., an extinction burst) and was moderately high and variable thereafter, with the overall mean rate of problem behavior higher than baseline levels ($M = 4.8$ responses per minute; range, 2.2 to 10.6). By contrast, problem behavior decreased in the first session of TBS card and remained at moderately low but slightly variable levels throughout the phase ($M = 1.4$ responses per minute; range, 0.2 to 2.6). For Frank, the TBS-card condition resulted in a mean reduction in problem behavior of 68% (calculated as 1 minus the mean from the final treatment phase divided by the mean from the initial baseline), whereas the TBS-vocal condition resulted in a mean increase in problem behavior of 20% relative to baseline.

It should be noted that reinforcer deliveries were accidentally paired with problem behavior in 17.4% of opportunities during the TBS-card condition and 28.6% during the TBS-vocal condition. Therefore, it may be that the higher rates of problem behavior that were observed during the TBS-vocal condition may be due to the higher percentage of accidental pairings between problem behavior and reinforcer delivery. However, accidental pairings occurred at least once (range, 1 to 5) in each TBS-card session. In addition, during two of the TBS-vocal sessions there were no scheduled time-based deliveries of reinforcement given that Frank did not emit a prompted or independent vocal mand during two of the FCT-vocal sessions from Study 1. At least one accidental pairing (range, 0 to 2) was observed in four of the remaining six TBS-vocal sessions in which time-based reinforcement delivery occurred.

Findings from the current study further support previous research that has indicated that dense schedules of reinforcement (TBS card) are more effective in reducing the occurrence of problem behavior than lean schedules of reinforcement (TBS vocal). This study extends TBS research by suggesting that duration of exposure to the EO may be a factor related to the greater effectiveness of dense schedules of reinforcement than lean schedules, at least during the initial stages of treatment. In addition, results of Study 2 provide support for the findings from Study 1 in that duration of exposure to the relevant EO for problem behavior may influence the effectiveness of FCT outcomes.

GENERAL DISCUSSION

In the current experiments, we evaluated the potential effects of duration of exposure to the relevant EO during treatment of problem behavior using two FCT interventions and two TBS interventions, with each treatment combined with extinction. In Study 1, we compared the effectiveness of two FCT interventions in terms of reduction of problem behavior and acquisition of an alternative response. One intervention was associated with limited exposure

to the EO (FCT card) and one with prolonged exposure (FCT vocal). Results of Study 1 showed that relative to the FCT-vocal condition, the FCT-card condition (a) produced larger and more rapid reductions in problem behavior, (b) produced more rapid acquisition of the mand, (c) was less likely to result in an extinction burst, and (d) was associated with lower durations of exposure to the EO for problem behavior.

The findings of Study 1 are consistent with our hypothesis that levels of problem behavior and acquisition of an alternative response during initial treatment with FCT plus extinction may partially be a function of the duration of exposure to the EO relevant to problem behavior. However, Study 1 left open the possibility that the observed findings were in part due to response-related variables. Therefore, in Study 2 we attempted to conduct a more direct test of our EO hypothesis using two TBS interventions: one yoked to the schedules of obtained reinforcement observed during the FCT-card condition and the other yoked to the FCT-vocal condition. Results of Study 2 were generally consistent with those of Study 1 in that (a) the TBS-card condition produced larger reductions in problem behavior than the TBS-vocal condition; (b) the TBS-card condition produced more rapid reductions in problem behavior than the TBS-vocal condition; and (c) the TBS-card condition did not produce an extinction burst, whereas the TBS-vocal condition did produce an extinction burst (as defined by Lerman & Iwata, 1995). Taken together, results of Studies 1 and 2 suggest that duration of exposure to the EO for problem behavior may be an important variable that influences the effectiveness of FCT and TBS as treatments for problem behavior. In addition, exposure to the EO may also affect the probability of whether or not extinction bursts will occur during reinforcement-based procedures used in conjunction with extinction.

John and Frank displayed lower rates of problem behavior and faster acquisition of the target mand in the FCT-card condition than in the FCT-vocal condition. Clinically acceptable reductions in problem behavior occurred rapidly and were maintained in the FCT-card procedure. Independent emission of the mand also occurred rapidly for both participants, and occurred at the first opportunity during the FCT-card condition (i.e., when the progressive prompt delay was increased from 0 s to 2 s). In addition, John's independent responding continued above criterion level (at least 85% of opportunities) in the FCT-card intervention across the intervention-comparison phase. By contrast, John displayed more variable levels of the mand during the FCT-vocal condition, exceeding the criterion level in only one session. Whether Frank would have also acquired the vocal mand more slowly remains unknown because the progressive prompt delay was never increased from 0 s for Frank in the FCT-vocal condition during the intervention-comparison phase.

The current findings have implications for the selection of mands when FCT is the planned intervention for individuals who display problem behavior. The results suggest that for individuals with limited vocal repertoires, even those who sometimes emit three- or four-word utterances, using a mand topography that can be physically guided (i.e., card touch) is likely to produce quicker acquisition of the mand and more rapid and larger reductions in problem behavior than using a mand that cannot be physically guided (i.e., vocal response). These results may potentially be due to the fact that when a mand is physically guided, the total duration of exposure to the EO relevant to problem behavior is decreased. This finding

is potentially important because behavior analysts may be inclined to select a vocal over a card-touch response because the former topography may be (a) better aligned with the individual's developmental goals (Charlop-Christy & LeBlanc, 1999) or (b) more recognizable to novel and untrained caregivers (Tiger et al., 2008). Given that both participants demonstrated the ability to emit the vocal response (either independently or when prompted), it may be that with additional training individuals with limited vocal verbal behavior would emit vocal mands for the functional reinforcer more consistently than the participants in the current investigation. However, given the results of the current study, it may be beneficial first to teach individuals an alternative response that can be taught through the use of physical prompts to diminish the occurrence of problem behavior. Future researchers should evaluate how and when to train a vocal response for individuals with limited verbal-vocal abilities (i.e., in conjunction with a card-touch response or after the card response is taught).

One way to determine when to select a card-touch response over a vocal response might be to conduct a pretreatment assessment similar to that described by Ringdahl et al. (2009). However, it may also be beneficial to measure the duration of exposure to the EO relevant to problem behavior and levels of problem behavior that are present during the assessment, because these variables, in addition to mand proficiency, may be related to the overall effectiveness of FCT. For both participants in the current investigation, differences in EO exposure, problem behavior, or both, were evident in the first session of each condition (even after just 2 min of exposure to each treatment). These findings are retrospective in nature and therefore should be interpreted cautiously. Nevertheless, they suggest that a brief pretreatment assessment could potentially predict the relative effectiveness of the FCT-card and FCT-vocal interventions. Whether such an assessment predicts treatment effectiveness prospectively across a larger group of participants should be evaluated in future research.

Previous research has shown that TBS procedures are more effective when the initial schedule of reinforcement is dense (e.g., Hagopian et al., 1994). Results of the TBS analysis conducted in the current investigation are consistent with this finding. Furthermore, the current results indicate that the levels of obtained rates of reinforcement influence duration of exposure to the EO, which in turn may affect levels of problem behavior in FCT. That is, higher levels of obtained reinforcement (as occurred in the FCT-card condition relative to the FCT-vocal condition) reduced exposure to the EO, which in turn influenced the speed and magnitude of reductions in problem behavior, the probability of an extinction burst, and acquisition of the mand during FCT.

Although the current results suggest that duration of exposure to the EO may be a factor related to the effectiveness of reinforcement-based procedures with extinction, some procedural limitations should be considered. First, for John (FCT-escape conditions) specific task instructions were presented only in the FCT-vocal condition because we could not physically guide a vocal response. Therefore, it may be that John was never truly exposed to the relevant EO for problem behavior (i.e., presentation of work) during the FCT-card condition and the vocal cue may have served as a conditioned reflexive motivating operation or warning signal that work was approaching but could be avoided through the emission of the communication response. Future investigations should ensure that exposure to the

relevant EO is present across FCT conditions when comparisons related to the effectiveness of procedures are evaluated.

A second potential procedural limitation is that both John and Frank were given somewhat long exposures to the EO during the FCT-card condition (although significantly less than in the FCT-vocal condition) given that the response was physically guided (see bottom panels of Figures 1 and 2). This was potentially related to one or more of the following: (a) data-recording errors, (b) lengthy vocal statements at the start of each 30-s trial, or (c) difficulty providing physical guidance (i.e., participant resistance). A final procedural limitation is that there were no set criteria for ending the FCT comparison phase; rather, treatment decisions were based on visual inspection for each participant. These criteria may be important not only for replication purposes but also for clearer identification of the more efficient and effective FCT intervention based on both reduction of problem behavior and acquisition of the response. Both participants' problem behavior was more variable during the FCT-vocal condition than in the FCT-card condition, but similar reductions in problem behavior were observed during the final sessions of the comparison phase across conditions. However, consistent and clinically significant levels of the communication response were observed in only the FCT-card condition. Furthermore, had specific criteria been in place for ending the comparison phase, it is likely that the phase would have ended sooner (e.g., after immediate and consistent reductions in problem behavior and increases in independent communication responses during FCT card).

Aside from the procedural limitations indicated above, there are additional concerns that should be considered and addressed in future research. First, we did not formally assess the participants' echoic and card-response repertoires, which could have provided additional guidance for the selection of individualized mands for the FCT-card and FCT-vocal conditions. Second, we did not formally assess response effort, proficiency, or preference for the mands selected for each participant in Study 1. To our knowledge, neither participant had prior history with the specific vocal response selected or with using a card touch as a mand. It should be noted, however, that we removed response-related variables as potential confounding factors in the TBS intervention comparison, because reinforcer deliveries occurred on a response-independent basis during this analysis. Thus, the potential response-related biases that may have affected the results of the FCT analysis were eliminated during the TBS analysis. Results of Study 2 suggest that the differences observed between the FCT-card and FCT-vocal conditions compared in Study 1 may have been in part due to differing durations of exposure to the EO rather than solely to differences related to the responses. Results from Study 2 replicate previous research that has indicated that TBSs of reinforcement differentially affect treatment outcomes.

A final limitation is that Study 1 and Study 2 did not demonstrate differential effects of duration of exposure to the EO using equivalent FCT responses. Therefore, future research should evaluate the effects of duration of exposure to the EO during FCT using the same mand modality across conditions (e.g., using card-touch responses in both conditions, but presenting opportunities to use the mand after short or long exposures to the EO).

Previous research has identified a number of variables that influence the effectiveness of FCT, including response effort, response proficiency, history, and preference. Despite the limitations noted above, the combined findings from Study 1 and Study 2 provide some evidence that duration of exposure to the relevant EO for problem behavior may also be a variable that affects the overall effectiveness of FCT and presence of extinction bursts during reinforcement-based procedures. Additional studies are needed to evaluate further the influence of duration of exposure to the EO during FCT in terms of reduction of problem behavior and acquisition of the alternative response.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

John's problem behavior per minute (top), independent mands (middle), and percentage of session with exposure to the establishing operation (EO; bottom).

Figure 2.

Frank's problem behavior per minute (top), independent mands (middle), and percentage of session with exposure to the establishing operation (EO; bottom).

Figure 3.
Problem behavior per minute during the time-based schedules (TBS) for Frank.