Journal of Applied Behavior Analysis

JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2018, **51,** 130–157 NUMBER 1 (WINTER)

# *ACHIEVING SOCIALLY SIGNIFICANT REDUCTIONS IN PROBLEM BEHAVIOR FOLLOWING THE INTERVIEW-INFORMED SYNTHESIZED CONTINGENCY ANALYSIS: A SUMMARY OF 25 OUTPATIENT APPLICATIONS*

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Jessel, Hanley, and Ghaemmaghami (2016) reported the results of 30 interview-informed, synthesized contingency analyses (IISCAs) and found the IISCAs to be an effective tool for identifying the functions of problem behavior across a variety of topographies, participants, and settings. Jessel et al. did not, however, include data on the effectiveness of the corresponding treatments. In the current study, we collected and summarized 25 additional applications, from analysis to treatment, in which the IISCA was applied in an outpatient clinic. The IISCA identified various social functions of problem behavior, which informed personalized treatments of functional communication training with contingency-based reinforcement thinning. A 90% or greater reduction in problem behavior was obtained for every participant by the end of the treatment evaluation. The assessment and treatment process was socially validated by caregivers who rated the procedures highly acceptable and helpful, and the improvement in their child's behavior highly satisfactory.

*Key words:* autism, functional analysis, problem behavior, functional communication training, reinforcement schedule thinning

Functional analysis of problem behavior involves systematic manipulation of antecedent or consequent events that might influence the occurrence of the behavior (Hanley, Iwata, & McCord, 2003). Functional analyses are conducted prior to treatment evaluations in an attempt to (a) identify the environmental causes of the problem behavior before it is treated, (b) establish a baseline from which to evaluate treatment effects, and (c) create a sufficiently motivating context to teach socially appropriate alternative behavior (Hanley, 2012). Functional analysis has become a staple in research on the assessment and treatment of problem behavior, because it has allowed for behavior change to be understood at the level of process. Functional analysis is likely to result in more efficacious treatment outcomes compared to when function is merely inferred from nonanalytic assessments or when behavior function is not considered prior to treatment (Campbell, 2003; Heyvaert, Saenen, Campbell, Maes, & Onghena, 2014; Kahng, Iwata, & Lewin, 2002). The efficacy of treatments based

This research was supported in part by a grant from Masonic Home and School of Texas. We thank Gregory Hanley for his helpful comments on earlier versions of this manuscript. Einar T. Ingvarsson is now at the Virginia Institute of Autism.

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doi: 10.1002/jaba.436

on functional analyses has been summarized in multiple outcome studies, which describe a number of clinical cases within single-subject designs. These studies have aggregated results of clinical cases treated in an outpatient setting (Kurtz et al., 2003), cases involving functional communication training (FCT) and supplementary treatment components (Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998; Rooker, Jessel, Kurtz, & Hagopian, 2013), and cases specific to reinforcement thinning procedures following FCT (Greer, Fisher, Saini, Owen, & Jones, 2016).

Greer et al. (2016) described 25 clinical applications of FCT based on functional analyses indicating socially mediated problem behavior. FCT involves reinforcing a communication response that specifies the reinforcer that maintains problem behavior, while placing problem behavior on extinction (Carr & Durand, 1985). Following reductions in problem behavior during FCT for 22 cases, reinforcement was thinned by introducing signaled periods in which reinforcement was not available (e.g., multiple schedule, response restriction). Ninety-one percent (20 of 22) of the cases reached 4- to 5-min delays to reinforcement while maintaining at least an 80% reduction in problem behavior. The authors reported replicating the standard functional analysis procedures described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994), as did the other outcome studies cited above (Hagopian et al., 1998; Kurtz et al., 2003; Rooker et al., 2013). However, social validity assessments were not included in any of these outcome studies. Therefore, the acceptability of the assessment process, treatments, or outcomes was not determined. Furthermore, multiple formats exist for conducting standard analyses prior to treatment, such as the brief (Northup et al., 1991), trial-based (Austin, Groves, Reynish, & Francis, 2015; Sigafoos & Saggers, 1995), or latency-based (Lambert et al., 2017; Thomason-Sassi, Iwata, Neidert, & Roscoe, 2011) formats. The treatment utility of these slight variations to the standard functional analysis format (Iwata et al.1982/1994) has yet to be evaluated in similar large-scale outcome studies.

Hanley, Jin, Vanselow, and Hanratty (2014) recently designed and evaluated a fundamentally different functional analysis format, named the interview-informed, synthesized contingency analysis (IISCA). The IISCA is informed by an interview with caregivers, and sometimes a brief observation, to determine evocative contexts, putative reinforcers, and specific materials to be included in an analysis. A single test condition is individualized for each patient from the assessment results and control conditions are then designed from the test condition to be the same except that the reinforcement contingency is absent in the control condition. IISCAs can involve multiple levels of individualization. First, the analysis materials and interactions can be individualized to match those that are reported by caregivers as evoking (e.g., specific tasks or instructions) or reinforcing (e.g., specific toy or a certain song) problem behavior. It is possible for a standard functional analysis to include this level of individualization; however, it is unclear how often this occurs, because many multiple-participant studies include a near-identical description of the initial functional analysis conditions with no apparent individualization (e.g., Fisher, Greer, Romani, Zangrillo, & Owen, 2016; Kurtz et al., 2003; Rooker et al., 2013; Wallace & Iwata, 1999). Second, the conditions/contingencies can be individualized in an IISCA to emulate the problematic context. Third, if a parent reports that the contingencies co-occur, they can be synthesized to more closely approximate the typical conditions in the client's home. If a parent implicates only positive reinforcement, a negative reinforcement contingency will not be included in an individualized analysis. This is a significant departure from the standard functional analysis

in which positive and negative reinforcement are always tested in isolated conditions and multiple test conditions are included in all analyses. Thus, the procedures of the standard functional analysis can be individualized, but it appears that researchers rarely do so.

Hanley et al. (2014) conducted the IISCA with three children diagnosed with autism, and implemented treatment for each child based on the results. The treatments consisted of teaching increasingly complex forms of communication during FCT. Reinforcement was then thinned by increasing the number of tasks or the duration of isolate play with nonpreferred materials that the participant was required to complete to earn the reinforcers. Hanley et al. effectively eliminated problem behavior while simultaneously teaching communication, toleration, and compliance. Caregivers also reported high satisfaction with the assessment process, treatment procedures, and treatment outcomes.

The general utility of the IISCA was recently described by Jessel et al. (2016), who summarized the results of 30 applications. The generality of the procedures was evident; the IISCA was conducted with children and adults (1.8 to 30 years old), with and without diagnoses (e.g., generalized anxiety disorder, attention deficit hyperactivity disorder), across a variety of problem behavior (i.e., aggression, disruption, self-injurious behavior [SIB], loud vocalizations), and in various settings (e.g., outpatient clinic, home, public school, day habilitation center). However, this study was limited to a summary of the assessment, without reports of subsequent treatment evaluations.

To date, there have been 15 published single-subject demonstrations of strong treatment effects when treatment was based on functions identified via the IISCA (e.g., Ghaemmaghami, Hanley, & Jessel, 2016; Ghaemmaghami, Hanley, Jin, & Vanselow, 2015; Hanley et al., 2014; Santiago, Hanley, Moore, & Jin, 2016; Slaton, Hanley, & Raftery, 2017; Strand & Eldevik, 2017). However, a large-scale evaluation of treatment effectiveness across consecutive clinical cases has not yet appeared in the literature.

We conducted the current study to determine the effectiveness of FCT and reinforcement schedule thinning following the IISCA functional analysis format. This research is a direct extension of Jessel et al. (2016), with the inclusion of treatment outcomes for a collection of clinical cases over a span of almost two years. We used FCT as a form of treatment for all participants, because it is the most commonly used function-based treatment (Tiger, Hanley, & Bruzek, 2008) and is empirically validated as treatment for the problem behavior of individuals diagnosed with intellectual disabilities and autism (Kurtz, Boelter, Jarmolowicz, Chin, & Hagopian, 2011). In Study 1, we summarized the results of 25 IISCAs for children with autism spectrum disorder (ASD) who had been admitted to an outpatient behavior disorders clinic due to problem behavior. In Study 2, we summarized the results of the FCT and reinforcement thinning procedures, as well as the results of a social validity assessment conducted with caregivers at the conclusion of their child's participation.

## STUDY 1: SUMMARY OF INTERVIEW-INFORMED SYNTHESIZED CONTINGENCY ANALYSES

### *Method*

*Participants and settings.* Twenty-five children from an outpatient clinic participated in this study. All patients were referred to the clinic due to severe behavior problems requiring outpatient services. The first 25 patients whose problem behavior was suspected to be maintained by socially mediated reinforcement were selected to participate. A total of 32 patients were screened at the outpatient clinic. Four patients were excluded because they did not exhibit problem behavior during any visits to

the clinic during a span of two weeks. One participant displayed a single topography of problem behavior (i.e., elopement) that prompted the use of a trial-based IISCA and treatment process relying on a latency measure. We excluded these data from the current paper due to these procedural differences. Another patient was excluded because we obtained an insufficient amount of interobserver agreement (IOA) data. Another patient's services were discontinued prior to the completion of the functional assessment period. The remaining 25 of the first 32 patients admitted to the outpatient clinic were included as participants. Three of the patients' (Anson, Robin, and Kat) functional analyses were also included in the publication by Jessel et al. (2016).

The demographic information of each participant is presented in Table 1. The majority of the participants were male (21 of 25) and the median age was 5 years (range, 2 to 15 years old). All but one participant had a diagnosis of ASD; Sarah was typically developing but had a diagnosis of Tourette syndrome. The participants' language ability upon intake ranged from nonvocal communication to vocal communication using full, fluent sentences. Based on parental reports and observation of the participants, we grouped most problem behavior into four possible categories: problem behavior directed toward others (aggression), problem behavior directed toward objects (disruption), problem behavior directed toward themselves (self-injurious behavior; SIB), and tantrums. The majority of participants had some combination of these topographical classes of problem behavior. Some participants also had less common forms of problem behavior such as loud vocalizations or spitting, and one participant displayed only inappropriate sexual behavior (ISB).

Patients admitted to the clinic were provided behavioral services 7 hr a day, 5 days a week, for 2 consecutive weeks. Assessment and treatment took place during the first week and parent training was conducted during the second week. Sessions were conducted in 3-m x 6-m and 3-m x 4-m treatment rooms, with at least one caregiver present to observe sessions throughout the entire assessment and treatment process. One therapist conducted sessions (primary implementer) while a second therapist collected data (primary data collector). The primary data collector also assisted during times between sessions. The therapists had undergraduate degrees in psychology or related fields, but did not have any graduate training in behavior analysis. The therapists were trained and supervised by the first author, a Board Certified Behavior Analyst-Doctoral (BCBA-D).

*Measurement and interobserver agreement.* We measured occurrences of multiple topographies of problem behavior. Aggression was defined as hitting, kicking, scratching, or biting others. Disruption was defined as tearing, throwing, and hitting items. SIB was defined as hitting, scratching, or biting self. A tantrum was defined as dropping to the floor and crying or whining for more than 30 s. Loud vocalizations were defined as yelling, screaming, or swearing. In addition, ISB was recorded for one participant who would attempt to touch other people's genital areas. The rate of problem behavior was calculated by dividing the session duration in minutes by the total number of responses within each session.

Some of the IISCAs included instructions to complete tasks. The instructions were provided to the participant in three steps: verbal prompt, model prompt, and physical prompt. Compliance was scored if the participant completed the task within 10 s of the first or second prompt.

Sessions were video recorded, and a second observer independently scored a portion of the videos to obtain interobserver agreement (IOA). IOA was calculated as total agreement by dividing the smaller number of responses within a session by the larger number. Total agreement was used in place of more

Table 1
Participant Characteristics

| Participant | Age | Sex | Diagnosis | Language Ability[a] | Problem Behavior |
|---|---|---|---|---|---|
| Joe | 5 | M | ASD | 1 | Agg, Dis, Tantrums |
| Anson | 7 | M | ASD, ID | 1 | Agg, Dis, SIB |
| Robin | 6 | F | ASD, ADHD | 3 | Agg, Dis, SIB |
| Kat | 4 | F | ASD | 1 | Agg, Tantrums, SIB |
| Ari | 15 | M | ASD, ID, ADHD | 4 | ISB |
| Lance | 4 | M | ASD, ID | 2 | Agg, Dis, Loud voc |
| Aaron | 7 | M | ASD, ADHD, ID | 2 | Agg, SIB |
| Stan | 5 | M | ASD, ADHD | 2 | Agg, Dis, Tantrums |
| Matt | 11 | M | ASD, GAD | 3 | Agg, Dis, Tantrums, Loud voc |
| Ken | 5 | M | ASD, ADHD, ID | 1 | Agg, Dis, Tantrums |
| Tim | 4 | M | ASD, ID | 1 | Agg, Dis, Tantrums |
| Zane | 3 | M | ASD, ID | 1 | Dis, SIB, Tantrums |
| Kane | 5 | M | ASD, ADHD, ID | 2 | Agg, Dis, Tantrums |
| Mike | 8 | M | ASD | 2 | Agg, Dis, Tantrums |
| John | 4 | M | ASD | 2 | Agg, Tantrums, Loud voc |
| Steve | 4 | M | ASD, ID | 1 | Agg, Tantrums |
| Max | 4 | M | ASD, ID | 3 | Agg, Dis, Tantrums |
| Alex | 2 | M | ASD, ID | 1 | Agg, Dis, SIB, Spitting |
| Sarah | 7 | F | Tourette syndrome | 4 | Agg, Dis, SIB, Tantrums |
| Annie | 5 | F | ASD, ADHD, ID | 3 | Tantrums |
| Dan | 6 | M | ASD, ADHD | 4 | Agg, Tantrums, Loud voc |
| Greg | 6 | M | ASD, ADHD | 2 | Agg, SIB, Tantrums, Loud voc |
| Dace | 11 | M | ASD, ID | 2 | Agg, Dis, SIB, Tantrums |
| Larry | 5 | M | ASD, ADHD, ID | 3 | Agg, Dis, SIB, Tantrums, Loud voc |
| Ace | 2 | M | ASD, ID | 1 | Aggression, SIB, Loud voc |

[a] 1 = non-vocal; 2 = 1-word utterances; 3 = short diffluent sentences; 4 = full fluency

*Note.* ASD is autism spectrum disorder. ID is intellectual disability. ADHD is attention deficit/hyperactivity disorder. GAD is generalized anxiety disorder. Agg is aggression. Dis is disruption. ISB is inappropriate sexual behavior. SIB is self-injurious behavior. Loud voc is loud vocalizations.

conservative IOA calculations due to clinical constraints on training therapists in other methods. We obtained IOA for 67% of sessions on average across participants (range, 40%-100%). The mean IOA across participants was 94% (range, 82%-100%). A summary of IOA for each participant is available as Supporting Information.

*Experimental design.* Two conditions, test and control, were included in every IISCA and compared in a multielement design. Sessions were conducted in a fixed sequence: control-test-control-test-test, with additional sessions of either condition conducted when necessary. Control conditions were always conducted first to build rapport with the participant in a context of rich reinforcement. The last two test sessions were conducted consecutively, without the interspersed control session, to ensure that rate of problem behavior was not a function of the patterned alternation of conditions.

*Procedure.* All IISCAs were preceded by a 15- to 30-min open-ended interview with caregivers and a 10- to 40-min semistructured observation of the child. The interview was conducted by a BCBA-D (the first author) and included questions pertaining to (a) the topography of problem behavior, (b) antecedents to problem behavior, (c) consequences following problem behavior, and (d) any other contextually relevant stimuli. The questionnaire used during the interview can be found in the appendix of Hanley (2012). During the observation, the clinician unsystematically arranged the contexts described as likely to evoke problem behavior. For example, a parent reported

that problem behavior was likely to occur when their child's independent play with a train set was interrupted with parent-directed play. In this instance, the therapist gave the child access to the train and observed what problem behaviors occurred when the therapist instructed the child to play with the train differently. Ari's case was unique due to the topography of his problem behavior (i.e., ISB). His parents reported that he would touch his sister or other girls inappropriately if they were playing with his iPad. As reported, his sister would then "feel uncomfortable" and either run away to tell the parents or simply go to a different area of the house, leaving Ari with the iPad. We therefore arranged for female therapists to remove Ari's iPad and return access only following ISB attempts.

Problem behaviors reported by parents, as well as any problem behavior that occurred during the observation but was not reported by caregivers during the interview, was included in the definition and measurement of target behavior. The information obtained from both the interview and observation was then used to create a single test condition and a matched control condition for the IISCA.

IISCA sessions were 3 to 10 min and involved delivery of the putative reinforcer(s) contingent on problem behavior in the test condition, and continuous noncontingent access to reinforcement in the control condition. The BCBA-D determined the initial session duration based on the problem behavior during the observation. If the evocative situation resulted in immediate problem behavior, the sessions were shorter (3 to 5 min). If lengthier exposure to the evocative situation was needed to evoke problem behavior, the sessions were extended to 10 min.

Relevant establishing operations were arranged at the beginning of each test condition session. The establishing operations were antecedent stimuli or events that were implicated by the interview and observation to evoke problem behavior related to the putative reinforcers (e.g., removing preferred items, presenting demands, directing the child's play). Any problem behavior that occurred during the presentation of the establishing operation resulted in the presentation of the putative reinforcer(s) for 30 s. If multiple reinforcers were synthesized, they were provided simultaneously. Any problem behavior during the 30-s presentation of the reinforcer resulted in no programmed changes. At the beginning of each control condition session, the abolishing operations were arranged. The abolishing operations were antecedent stimuli or events that were implicated by the interview and observation to eliminate problem behavior related to the putative reinforcers from the test condition (e.g., access to preferred items, no demands, unstructured play). Any problem behavior that occurred during the control condition resulted in no environmental changes. Thus, the test and control conditions were matched and included all of the same stimuli. The only difference between the conditions was the motivating operations (i.e., establishing vs. abolishing) and the method of reinforcer delivery (i.e., contingent on problem behavior vs. noncontingent).

Table 2 provides a brief summary of the procedures for each participant. For 20 of 25 participants, we included some form of negative reinforcement in the test condition. The negative reinforcement contingency took the form of escape from transitions (4 of 20), escape from interactive or adult-directed play (4 of 20), or escape from some form of instruction (9 of 20). The negative reinforcement contingencies for some participants were more individualized, and included escape from adult attention (Robin), specific gross-motor instructions (Kat), working with others present (Matt), and parent-selected DVDs (Tim).

The IISCA for 23 of the 25 participants included some form of positive reinforcement. Many of these conditions included one of three possible forms of play: independent, interactive,

Table 2
Summary of Procedures

| Participant | Session (min) | FA Test Condition | FCR | | Final Schedule | |
|---|---|---|---|---|---|---|
| | | | Initial | Terminal | Tasks (#) | Duration (s) |
| Joe | 10/20 | Escape from transitions to iPad | *My* | *My way* | -- | 5/180/300 |
| Anson | 5/10/20 | Escape from interactive to independent play | 4x4 icon | 2x2 icon in binder | -- | 1/15/30 |
| Robin | 5/5 | Escape from adult interaction | *My time* | *My time please* | -- | -- |
| Kat | 5/10/20 | Escape from gross motor instructions to independent play | 4x4 icon | 2x2 icon in binder | 1/12/24 | -- |
| Ari | 10/20/40 | Access to iPad | FCR1[a] | FCR2[b] | -- | 300/600/900 |
| Lance | 5/10/20 | Access to interactive play | *My* | *My way* | 1/10/20 | -- |
| Aaron | 10/10 | Escape from transitions to child-directed play | *My way* | *My way please* | 1[c] | -- |
| Stan | 5/10/20 | Escape from instructions to independent play | 4x4 icon on toy | 4x4 icon with *my way* | 1/12/24 | 5/60/180 |
| Matt | 5/10/20 | Escape from transitions and group work to independent work | *Excuse me, may I work here please* | *Excuse me* [name]. *May I work here please* | 1/8/16 | -- |
| Ken | 5/10/20 | Escape from instructions to independent play | 4x4 icon | 2x2 icon in binder | 1/16/32 | -- |
| Tim | 5/10/20 | Escape from parent-selected DVDs to child-selected DVDs | 4x4 icon | 2x2 icon in binder | 1/12/24 | -- |
| Zane | 5/10/20 | Escape from instructions to independent play | 4x4 icon | 2x2 icon in binder | 1/24/48 | -- |
| Kane | 5/10/20 | Escape from transitions to interactive play | *My time* | *My time please* | 1/24/48 | 30/180/300 |
| Mike | 5/10/20 | Escape from interactive to independent play | *My way* | *My way please* | -- | 30/120/180 |
| John | 5/10/20 | Escape from instructions to interactive play | *My way* | *Excuse me, my way please* | 6/18/42 | -- |
| Steve | 5/10/20 | Escape from instructions | 4x4 icon | 2x2 icon in binder | 3/20/40 | -- |
| Max | 5/10/20 | Access to child-directed play | *My toys* | *My toys please* | -- | 10/60/120 |
| Alex | 5/10 | Escape from instructions to interactive play | 4x4 icon | 2x2 icon in binder | 2/6/12 | -- |
| Sarah | 5/10/20 | Escape from parent instructions to child-directed play with parent | *Excuse me, can I have my way please* | *Excuse me, can I have my way please? Let's play with the* [item] | 5/24/48 | -- |
| Annie | 10/20 | Escape from adult-directed to child-directed play | *My way please* | *Excuse me, may I have my way please?* | 5/24/50 | -- |
| Dan | 5/10/20 | Escape from parent-directed to child-directed play with parent | *My way please* | *Excuse me, may I have my way please?* | 3/12/24 | -- |
| Greg | 3/5/10/20 | Access to interactive play | *My way* | *Excuse me, my way please* | 5/25/50 | -- |
| Dace | 10/20 | Escape from instructions to independent play | *My time* | *My time please* | 3/6/12 | -- |
| Larry | 5/10 | Escape from blocked to free access of leisure items | *My way* | *My way please* | 3/12/24 | -- |
| Ace | 3/5/10/20 | Access to interactive play | 4x4 icon | 2x2 icon in binder | -- | 30/120/420 |

*Note*. Dashes indicate that the reinforcement thinning procedure was not used. The values in the Session column represent the initial/transitional/terminal session durations. The values in the Tasks column represent the easy/moderate/difficult sets of instructions. The values in the Duration column represent the easy/moderate/difficult delay requirements.

[a] *Excuse me* [name], [name] *took my* [item]. *Could you please help me get it back?*

[b] Two responses were included specifying whether or not the item was taken away during his turn.

[c] Aaron's terminal goal involved complying with prompts to transitions to the other places. The complexity was increased based on distance and reported difficulty transitioning to those locations.

and child-directed. During independent play (7 of 23), the therapist did not provide any attention and gave the child at least 1 m of space to engage independently with her or his

preferred leisure items. During interactive play (6 of 23), the therapist provided verbal and physical attention while the participant engaged with the preferred items. During child-directed play (5 of 23), the therapist honored any requests made by the participants and only interacted with them following bids for attention. For two participants (Joe and Ari), the positive reinforcement contingency involved the delivery of only one item, an iPad. For one participant (Tim), the positive reinforcement was specific to DVDs that he selected. The positive reinforcement for Matt was access to independent academic work.

We included a synthesized contingency of both positive and negative reinforcement for the majority of participants (19 of 25). We implemented isolated positive reinforcement with four participants (Ari, Lance, Max, and Greg) and attempted to isolate negative reinforcement with two participants (i.e., no positive reinforcement was programmed during the escape interval for Robin and Steve). The contingencies were tested in isolation when the results of the interview and observation suggested that they did not co-occur with other putative contingencies.

*Results and Discussion*

The results of the 25 IISCA applications are presented in Figure 1. Higher rates of problem behavior were observed across participants during the test condition ($M$ = 1.5 RPM; $SD$ = 1.04) relative to the control condition ($M$ = 0.02 RPM; $SD$ = 0.07). For 20 out of 25 participants, there was no overlap between the test and control conditions. In four cases in which overlap occurred, it was due to problem behavior occurring at low or zero rates at the beginning of the analysis. No problem behavior was observed during the control condition for 22 out of 25 participants. For most of the IISCAs, the minimum number of sessions (i.e., five) was sufficient because of the limited overlap and near elimination of problem behavior during the control condition. Fourteen participants required five sessions total, six participants required six sessions, and the remaining five participants required seven or more sessions. Based on the number of sessions and the duration of each session, the mean duration of the analysis was 35.6 min and the median was 25 min.

We replicated the results of previous research (Jessel et al., 2016), and the results support the IISCA as an efficient tool for determining socially mediated functions of problem behavior. The brevity of functional analysis is an important parameter to consider for practical reasons, as suggested by the multiple functional analysis formats designed for that purpose (e.g., Northup et al., 1991; Thomason-Sassi et al., 2011). There are at least two clinically guided purposes for using formats that require less time to conduct. First, identification of behavioral function requires the target response to occur and be reinforced. Because the target response during a functional analysis is problem behavior, it is best to (a) obtain only an amount of problem behavior necessary to detect a difference between the test and control conditions (i.e., there is no benefit and only greater risk when problem behavior occurs at a rate exceeding that expected by the reinforcement period duration—e.g., 2 per min with 30 s reinforcement intervals), and (b) minimize its exposure to reinforcement. Extended exposure to reinforcement could lead to initial resistance to treatment (see Nevin & Shahan, 2011 for a review of behavioral momentum in application). On the other hand, avoiding functional analysis altogether leads behavior analysts to rely on highly inferential indirect or descriptive assessment tools (Iwata, DeLeon, & Roscoe, 2013; Lerman & Iwata, 1993) that yield only information about the prevalence of antecedent and consequences without any means to understand the relevance of those events to problem behavior (Hanley, 2012; Iwata & Dozier, 2008). An efficient functional analysis format is

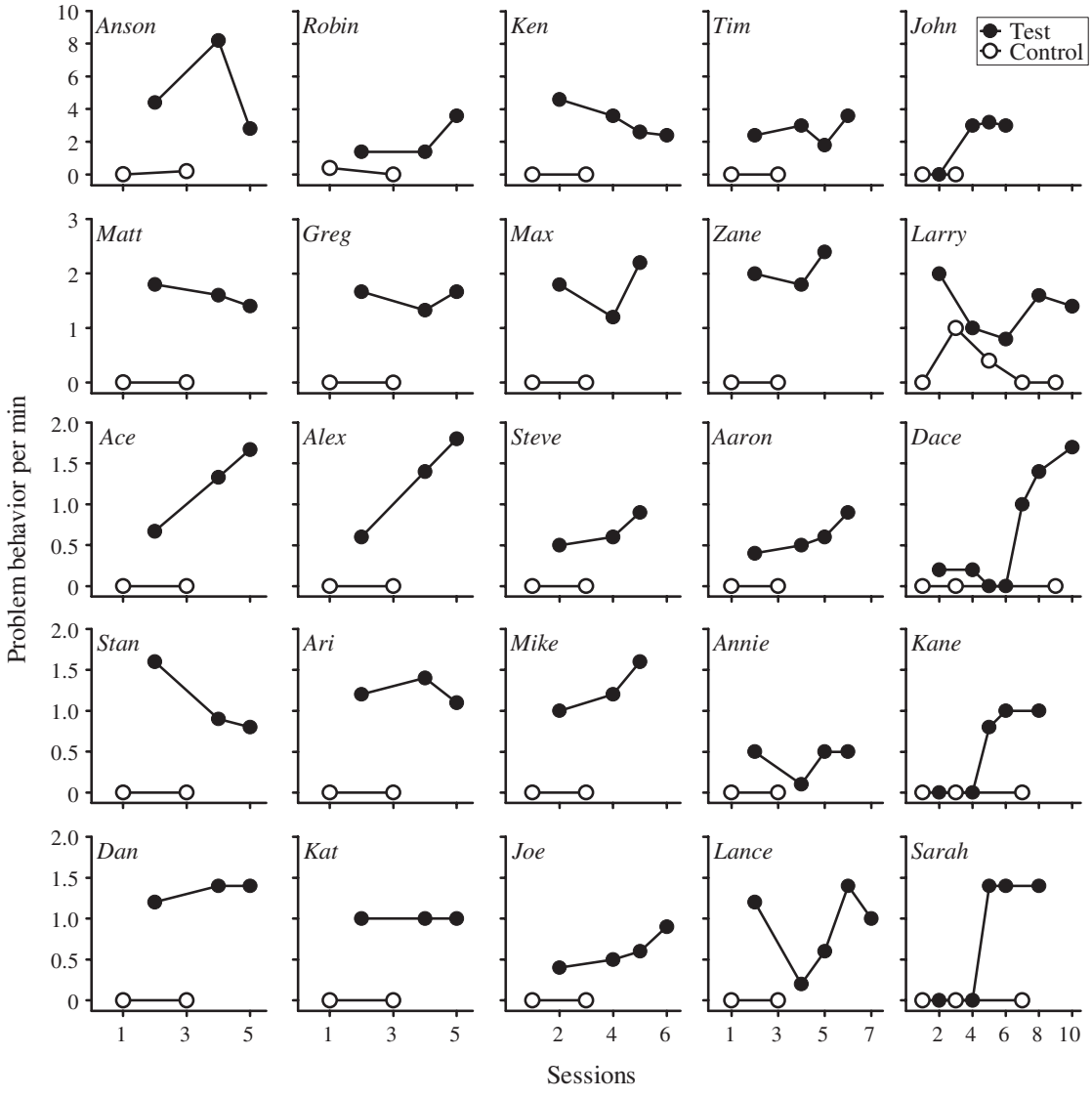


Figure 1. Results of the 25 interview-informed, synthesized contingency analyses (IISCAs).

likely to limit reinforcement of problem behavior while still establishing the necessary conditions to understand its reinforcement sensitivity prior to intervention.

Second, an important goal for practitioners when treating problem behavior is to identify effective function-based treatment (McComas & Mace, 2000). The functional analysis is a strategy that may meet this end, but time constraints appear to preclude its adoption by practitioners (Oliver, Pratt, & Normand, 2015; Roscoe, Phillips, Kelly, Farber, & Dube, 2015). Northup et al. (1991) estimated that a standard functional analysis is likely to require 40 to 60 sessions. Considering the sessions of the standard functional analysis are typically 10-15 min, this results in an analysis requiring between approximately 7 and 15 hrs to conduct. Therefore,

conducting a standard functional analysis may be outside the reach of practitioners who do not work in inpatient settings. The IISCA provides a viable solution, because it typically requires as little as 25 min to complete. However, the duration of the interviews and observations that inform the IISCA are not reported in the current study, and it is unknown how much these preassessments precisely influence the brevity of the analysis. A comparison of efficiency that includes preassessment duration cannot be achieved, because the precise duration of preassessments are not typically reported for either the IISCA or the standard functional analysis formats. Furthermore, this comparison may be unnecessary considering that the *maximum* duration of the IISCA interview and observation (70 min) added to the median analysis duration (25 min), is still less than the time it takes to conduct a standard functional analysis.

Efficiency is, in part, achieved during an IISCA by conducting a single test condition in which the suspected contingencies are emulated and synthesized, rather than multiple test conditions in which typical contingencies are evaluated in isolation. Synthesis reduces experimental precision, because the effects of individual contingencies (e.g., escape vs. tangible) are not isolated (Fisher et al., 2016; Hanley et al., 2014). Although ecological precision is clearly improved by more closely approximating the natural environment, it is unclear whether an analysis that capitalizes on possible interactive effects of multiple naturally occurring consequences improves or reduces treatment effectiveness. A recent study by Slaton et al. (2017) suggests that improvement in treatment outcome may be more likely with synthesized contingencies (which favor ecological over experimental precision). The within-subject comparative analyses showed that function-based treatments designed from IISCAs were efficacious in four of four applications whereas function-based treatments designed from differentiated standard analyses for the same four participants were efficacious in only two of four applications.

The results of Slaton et al. (2017) and other studies that have shown treatment efficacy (Ghaemmaghami et al., 2015; Ghaemmaghami et al., 2016) or treatment effectiveness *and* social validation of the treatment effects (Hanley et al., 2014; Santiago et al., 2016; Strand & Eldevik, 2017) provides strong evidence of the utility of the IISCA in designing treatments for severe problem behavior. These studies show what is *possible* from an IISCA. It is still not at all obvious whether it is *probable* that an effective outcome will result from an IISCA. By effective, we mean outcomes showing zero or near-zero rates of problem behavior, the maintenance of newly acquired and important social skills, and high satisfaction with the outcomes by relevant caregivers. The purpose of Study 2 was to describe the probability of these outcomes with all participants from Study 1 and then to compare these outcomes to those obtained in other outcome studies in which standard analyses were used as the basis for treatment.

## STUDY 2: SUMMARY OF TREATMENT OUTCOMES FROM THE IISCA

### *Method*

*Participants and settings.* Sessions were conducted in the same settings and with the same participants as in Study 1.

*Measurement and interobserver agreement.* The measurement of problem behavior and compliance was identical to Study 1. In addition, different forms of communication and the duration of time without reinforcement were recorded. To record the duration of time without reinforcement, a timer was started when reinforcers were removed and stopped every time reinforcers were re-presented. This measure was included to determine tolerance for delays to reinforcement during reinforcement thinning. Participants were taught a minimum

of three different topographies of functional communication responses (FCRs), differing in complexity. The complexity of the FCR was dependent on the participants' initial verbal abilities (Table 1) and was gradually increased to a more socially appropriate level throughout the treatment.

The definition of each participant's FCRs is presented in Table 2. Nine participants were nonvocal and their simple FCR involved handing the therapist a 10.2 cm x 10.2 cm picture card that was placed directly in front of them. The larger picture cards were used as a simple FCR for all nonvocal participants to ensure that the initial treatment included a low effort and novel response. The complexity of these responses was increased to a terminal goal of handing over a 5.1 cm x 5.1 cm card located inside a binder. The simple FCRs for participants who had vocal verbal behavior varied; however, the majority were two word phrases (e.g., "My way"). Phrases such as "my way" were used because they (a) can be expanded to more complex phrases (e.g., "May I have *my way* please"), (b) properly identified the general class of multiple different reinforcers, and (c) were unlikely to have historical relation to problem behavior due to their novelty (Winborn, Wacker, Richman, Asmus, & Geier, 2002). The terminal complexity of the vocal FCRs included an interaction with the therapist in which the participant first requested his or her attention (i.e., "Excuse me?"). Following a response from the therapist, the participant completed the phrase (e.g., "May I have my way please?). The complex FCR was scored only if the participant emitted both the request for attention and request for reinforcement.

The participants were also taught a tolerance response to denials of reinforcement. Denials occurred when the experimenter said "Nope," "Not right now," or a similar phrase in response to participant requests. For the nonvocal participants, the tolerance response involved placing their hands together or handing over an additional picture card with the printed phrase "No problem." The tolerance response for the vocal participants included some variation of the phrase, "Okay, no problem" while placing their hands together. Observers scored the number of occurrences for all of the different forms of communication. For each response, the count was converted to a rate by dividing the sum by the duration of the session in minutes. Observers also scored duration of reinforcement access. Onset of reinforcement access occurred when the experimenter delivered the reinforcer, and offset occurred when the experimenter removed the reinforcer.

The IOA for the frequency measures was calculated as a total agreement. The IOA for duration of time without reinforcement was calculated by dividing the shorter duration by the longer duration for each session. The IOA for each participant is presented in the Supporting Information. A second observer independently collected data for IOA purposes during a mean of 27% of sessions (range, 17%-38%). The mean IOA across participants for problem behavior, FCRs, tolerance response, reinforcement, and compliance was 94% (range, 82%-100%), 98% (range, 86%-100%), 97% (range, 87%-100%), 90% (range, 87%-94%), and 97% (range, 85%-100%), respectively.

*Experimental design.* Following a baseline condition, the treatment for each participant was evaluated using the logic of a changing criterion design (Kazdin, 1982). The effects of the contingency were evaluated across a minimum of three possible criteria (i.e., simple FCR, complex FCR, tolerance response), gradually increasing the complexity of a participant's response for the identified reinforcers. In some cases, a fourth response criterion was included with the addition of a second complex FCR. Functional control was demonstrated when the rate of each level of communication changed in a predictable direction with the change in the reinforcement contingency. A reversal back to the baseline condition was not conducted

because it was counter-therapeutic and a demonstration of functional control during a changing-criterion design does not require withdrawing the treatment (Kazdin, 1982).

*Procedure.* The test conditions from the IISCA served as the baseline for the treatment evaluation. The results of the IISCA were also used to inform the results of the subsequent skill-based treatment. The participants were first taught a novel response that produced the identified reinforcers. In addition, those reinforcers were withheld following any instances of problem behavior. For example, if we found a participant's problem behavior to be maintained by escape from adult-directed play and access to child-directed play, the participant would have access to child-directed play only following instances of the target response, "My way." If problem behavior occurred, the therapist would continue to direct the participant's play.

The participants were first taught to emit the FCR during FCT. To teach vocal FCR responses, the therapists used a progressive prompt-delay procedure (Charlop, Schreibman, & Thibodeau, 1985). The prompt-delay procedure began with an immediate verbal model of the target FCR. The prompt was then progressively delayed to 2 s, 5 s, and 10 s depending on the participants' independent communication. To teach responses that involved exchange of a picture card, the therapists used most-to-least prompting. Trials began with an immediate full physical prompt to hand the therapist the picture card. The full physical prompt was then faded to partial-physical and gestural prompts as the participants began to independently hand the therapist the picture card. Problem behavior was placed on extinction during the FCT training trials; if any problem behavior occurred, the therapists withheld the reinforcers that had been identified in the IISCA. Each session was 10 trials, and mastery criteria were set at two sessions with a minimum of 70% independent correct responding and fewer than three instances of problem behavior. FCT training trials were conducted in a minimum of three phases, each phase for the different form of communication. The FCT treatment evaluation began following mastery of each communication response.

The FCT treatment evaluation involved presenting the reinforcer(s) contingent on each instance of the target communication response while problem behavior was placed on extinction. Although prompts for the FCRs were removed, every 30 s the participants were provided with a reminder of the target response (e.g., "Remember, you can always say 'my way' if you want to play your way"). The reminder was only delivered if the participant had not engaged in the FCR and if problem behavior was not occurring at the moment. As stated above, the treatment was evaluated across a minimum of three forms of communication. Each new communication-training phase was initiated following three consecutive sessions with fewer than three instances of problem behavior. During the FCT treatment evaluation, sessions were either 5 or 10 min. The duration of the session was identical to the session duration during each participant's IISCA.

The treatment evaluation began after the participant acquired the simple FCR during the FCT training trials. During the first phase of the treatment evaluation, the simple FCR produced the reinforcer(s). When the mastery criteria were met, FCT training trials began for the complex FCR. Following mastery of the complex FCR, the second phase of the treatment evaluation was implemented, during which the complex FCR produced the reinforcer(s) while both the simple FCR and problem behavior were placed on extinction. In some cases, this process was repeated a third time to teach the participant another complex FCR. For example, a participant could have originally been taught the FCR, "My way." Following mastery, "My way" would be placed on extinction and a new FCR of "My way,

please" would be reinforced. At this point, all of the previously targeted FCR forms would no longer be reinforced and the terminal complexity, "May I have my way please" would be taught. After three sessions with near zero rates of problem behavior during the final FCT treatment evaluation phase, training began for the tolerance response. When the participant had mastered the tolerance response, another treatment evaluation phase was implemented. In this phase, 50% of trials were identical to the last phase of FCR treatment evaluation, while the other 50% were "tolerance" trials. In the latter trial type, the FCR response was not reinforced; instead, the therapist said, "Not now." If the participant emitted the tolerance response, reinforcement was delivered. Tolerance trials and FCR trials were randomly interspersed, and the simple FCR and problem behavior were placed on extinction. Reinforcement thinning began following three sessions with little to no problem behavior during the tolerance response evaluation.

We conducted reinforcement thinning using the procedures described by Ghaemmaghami et al. (2016) for 24 of the 25 participants. Robin did not participate in the reinforcement-thinning phase because following the FCT treatment evaluation, her FCRs were on a decreasing trend and problem behavior remained low throughout the day. Robin was therefore deemed no longer to need intensive services specifically targeting problem behavior, and began to receive different clinical services. For the other participants, duration of reinforcer access was gradually reduced by introducing delay-to-reinforcement trials. These trials were randomly interspersed with trials in which immediate reinforcement was programmed for the complex FCR and tolerance response (see Figure 2).

For some participants, the duration of the delay depended on compliance to a set number of task demands (Figure 2, top panel). This reinforcement thinning procedure can be conceptualized as a chained schedule using differential reinforcement of alternative behavior (DRA). During a delay-to-reinforcement trial, when the participant emitted the complex FCR, the therapist said, "Not now," which set the occasion to emit the tolerance response. Following the tolerance response, the participant was provided a set number of demands to complete before the reinforcer was re-presented. The instructions were identical to those used during the IISCA and were participant-specific, based on the reports by the caregivers from the interview. For example, if adult-directed play was a problematic context, the therapist would provide the participants with instructions such as, "Put this puzzle piece in next" or "Make this car go up the tracks." If problem behavior occurred during the delay, the number of tasks the participant was required to complete was reset. This DRA-based reinforcement thinning approach was used when parents reported problem behavior or noncompliance during instructions.

For other participants, the duration of the delay depended only on whether or not problem behavior occurred (Figure 2, bottom panel). This reinforcement thinning procedure can be conceptualized as a chained schedule using differential reinforcement of other behavior (DRO). Instead of demands being presented, the participant had to engage in any form of appropriate behavior without problem behavior. This could include engaging with other items (nonpreferred) or completing supervised transitions to other locations. The nonpreferred items were those the participants did not select during preference assessments that were conducted multiple times per day (see Ghaemmaghami et al., 2016). The nonpreferred items were included if caregivers reported having difficulty completing household tasks because the extent of the participants' problem behavior required constant supervision. When the delay was introduced, the participant was provided an instruction

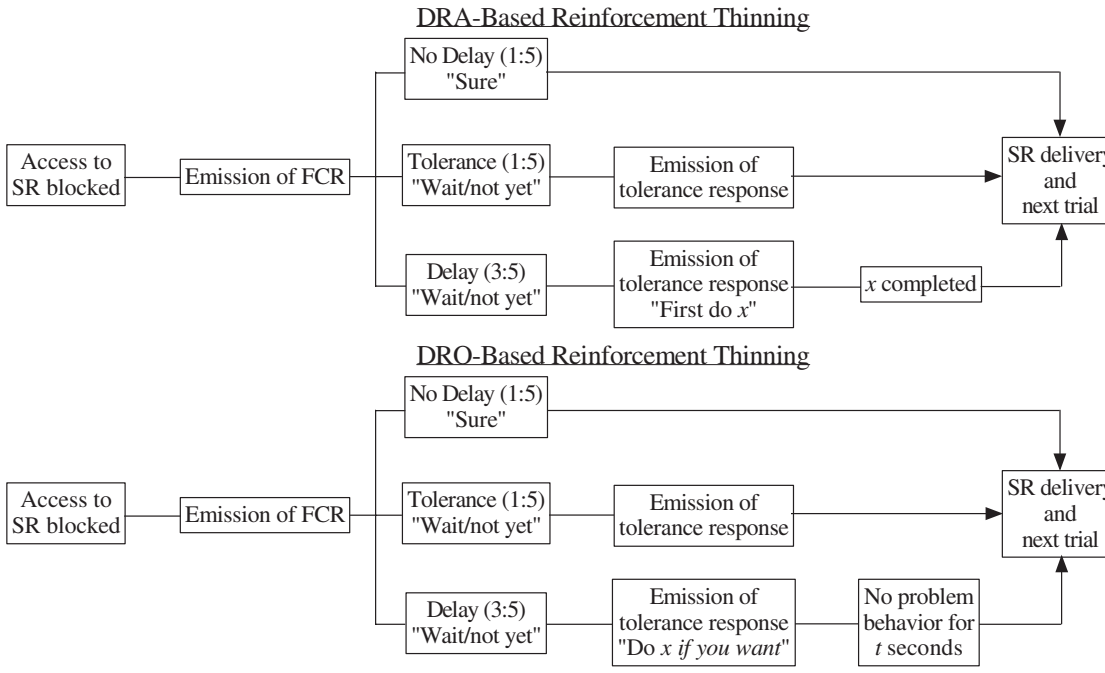


Figure 2. A schematic of the procedures used during DRA-based reinforcement thinning (top panel) and DRO-based reinforcement thinning (bottom panel). Numbers in the parentheses refer to the ratio of those trials occurring in a session.

such as, "[preferred items] are not available but you can play with the [nonpreferred items] if you would like." Access to the items was presented as a choice and the participant was not required to play with the items in order for the reinforcers to be delivered at the end of the DRO interval. The supervised transitions were included if caregivers reported not being able to take the participant to any locations away from their preferred items. If problem behavior occurred during the DRO interval, the duration requirement was reset.

The number of demands and duration requirements were progressively increased contingent on two consecutive sessions of little to no problem behavior. In addition, three levels of delays were randomly interspersed within each session during each step of the thinning procedure. The levels differed in difficulty based on the number of demands or the duration of the delay. Therefore, there were five different types of trials a participant could experience, and a different response was scheduled for reinforcement on each trial. Each session consisted of an equal proportion (i.e., .20) of trials including a complex FCR, tolerance response, easy level demands/delay, moderate level demands/delay, or difficult level of demands/delay. The sequence of trials was determined by a random number generator; however, all five trial-types had to occur before any of them could be repeated. Session duration during reinforcement thinning was increased to 20 min for most participants. Sessions were extended to accommodate the delay interval when the programmed delay was longer than the session duration. The entire treatment package involved the intermittent and unpredictable reinforcement of communication, toleration, and compliance chains.

*Social validity evaluation.* Caregivers completed two questionnaires as a part of the intake

and discharge process in the outpatient clinic. The first questionnaire (see Supporting Information) was provided during an intake meeting and again during the discharge meeting, and included two sets of 40 questions related to daily situations (e.g., school, peer interactions, meal time) and problem behavior (e.g., aggression, self-injury, general problem behavior). The caregivers were asked to rate whether or not each situation or behavior mentioned was a problem on a scale from "Almost never presents a problem" to "Presents a serious problem." The number of situations and behaviors the caregivers rated as being a serious problem was then compared before and after the child's 2-week participation in the assessment and treatment process.

The second questionnaire was administered during the discharge meeting, and involved a set of questions concerning caregivers' satisfaction with the improvements observed and how acceptable they found the recommended treatment. Caregivers were asked to rate all the items on a 7-point Likert-type scale ranging from not acceptable/satisfied/helpful to highly acceptable/satisfied/helpful.

*Results and Discussion*

The reductions in problem behavior across phases for each participant are presented in Table 3. Elevated rates of problem behavior were observed across participants during baseline ($M$ = 1.65 RPM, $SD$ = 0.98). During the initial phase of the treatment evaluation, problem behavior was eliminated for 18 out of 25 participants. Overall, a 95% reduction in problem behavior was observed across all participants ($M$ = 0.04 RPM, $SD$ = 0.09). When the complex FCR was taught in the final phase of the treatment evaluation, problem behavior remained low ($M$ = 0.06, $SD$ = 0.1), with complete elimination observed for 60% (15 of 25) of the participants. For 48% of the participants (12 of 25), complete elimination of problem behavior was achieved during the entire FCT treatment evaluation prior to reinforcement thinning. The rate of problem behavior remained low during reinforcement thinning, with complete elimination observed with three participants, at least 90% reduction observed with 16 participants, and at least 80% reduction across all participants.

The means presented above were calculated from complete phases. However, in previous outcome studies, results have typically been evaluated by calculating means using only the final portions of baseline and treatment phases (e.g., Greer et al., 2016; Hagopian et al., 1998; Rooker et al., 2013; Wacker et al., 1998). For example, the percentage reduction in problem behavior could be calculated using only the last three or five sessions of baseline and the last three or five sessions of treatment. To allow for comparison with previous studies, we conducted an additional data analysis of problem behavior reduction comparing the last three sessions of baseline and the last three sessions of treatment. We included the last three sessions because the baseline phase for the majority of our participants only required three points. The treatment outcome for each participant is presented in Table 3 and summarized in Figure 3. Overall, problem behavior was largely eliminated for 15 participants, with the rate of problem behavior for all participants reduced by at least 90%. In addition, we used a Wilcoxon signed-rank test to compare the rates of problem behavior before and after the introduction of the treatment. The Wilcoxon signed-rank test is a nonparametric statistical analysis designed to analyze two dependent sets of data (Wilcoxon, 1945). We found the results to be statistically significant ($Z$ = -4.37, $p < .001$).

The terminal schedules for each participant during reinforcement thinning are presented in Table 2. The DRA-based reinforcement thinning procedure was used with 15 of the 25 participants. The terminal task requirement ranged from 16 to 50 instructions. An example of the treatment process, using a DRA-based

Table 3
Problem Behavior per Min and Percentage Reduction across Assessment and Treatment Phases for 25 Consecutive Participants

| | | Treatment | | | |
|---|---|---|---|---|---|
| | | Treatment Evaluation | | | |
| Participant | Baseline (Final 3) | Initial | Terminal | Reinforcement Thinning | Outcome (Final 3) |
| Joe | 0.6 | 0 (100%) | 0 (100%) | 0.04 (93%) | 0 (100%) |
| Anson | 5.13 | 0.4 (92%) | 0.16 (97%) | 0.14 (97%) | 0.03 (99%) |
| Robin | 2.13 | 0 (100%) | 0 (100%) | -- | 0 (100%) |
| Kat | 1 | 0 (100%) | 0.05 (95%) | 0.13 (87%) | 0 (100%) |
| Ari | 1.23 | 0.07 (94%) | 0.01 (99%) | 0.01 (99%) | 0.02 (98%) |
| Lance | 0.88 | 0 (100%) | 0 (100%) | 0.01 (99%) | 0 (100%) |
| Aaron | 1.6 | 0 (100%) | 0.3 (81%) | 0.14 (91%) | 0.1 (94%) |
| Stan | 1.1 | 0.03 (97%) | 0.3 (73%) | 0.15 (86%) | 0 (100%) |
| Matt | 1.6 | 0.04 (97%) | 0 (100%) | 0.07 (96%) | 0 (100%) |
| Ken | 3.3 | 0 (100%) | 0 (100%) | 0.14 (96%) | 0.02 (99%) |
| Tim | 2.8 | 0 (100%) | 0 (100%) | 0.05 (98%) | 0 (100%) |
| Zane | 2.07 | 0.16 (92%) | 0 (100%) | 0.07 (97%) | 0 (100%) |
| Kane | 0.93 | 0 (100%) | 0 (100%) | 0.13 (86%) | 0.02 (98%) |
| Mike | 1.27 | 0 (100%) | 0.2 (84%) | 0 (100%) | 0 (100%) |
| John | 3.07 | 0 (100%) | 0 (100%) | 0.08 (97%) | 0 (100%) |
| Steve | 0.67 | 0 (100%) | 0 (100%) | 0 (100%) | 0 (100%) |
| Max | 1.73 | 0.18 (90%) | 0.24 (86%) | 0.08 (95%) | 0.02 (99%) |
| Alex | 1.27 | 0 (100%) | 0.12 (91%) | 0.24 (81%) | 0.13 (90%) |
| Sarah | 1.4 | 0 (100%) | 0 (100%) | 0 (100%) | 0 (100%) |
| Annie | 0.4 | 0 (100%) | 0.05 (88%) | 0.06 (86%) | 0 (100%) |
| Dan | 1.33 | 0 (100%) | 0 (100%) | 0.16 (88%) | 0.08 (94%) |
| Greg | 1.56 | 0.13 (91%) | 0 (100%) | 0.18 (88%) | 0.07 (96%) |
| Dace | 1.37 | 0 (100%) | 0 (100%) | 0.03 (97.8%) | 0 (100%) |
| Larry | 1.27 | 0 (100%) | 0.07 (95%) | 0.23 (82%) | 0.1 (92%) |
| Ace | 1.22 | 0 (100%) | 0 (100%) | 0.04 (97%) | 0 (100%) |
| *Mean* | *1.65* | *0.08 (95%)* | *0.06 (96%)* | *0.1 (94%)* | *0.02 (99%)* |

*Note*. The number in the parentheses represents the percentage reduction from the functional analysis test condition. Outcome refers to the mean of the final three sessions from the treatment. All other means include entire data sets from each treatment phase.

reinforcement thinning procedure with one participant, is presented in Figure 4. John exhibited high rates of problem behavior during the baseline phase ($M$ = 3.07 RPM, $SD$ = 0.12). When the reinforcers identified during the functional analysis were presented contingent on the simple FCR, problem behavior was eliminated and elevated rates of the simple FCR were observed ($M$ = 1.67 RPM, $SD$ = 0.12). The reinforcers were then presented contingent on the complex FCR1. The problem behavior remained at zero, elevated rates of the complex FCR1 were observed ($M$ = 1.4 RPM, $SD$ = 0), but the rates of the simple FCR1 dropped to zero. During the final phase of FCT, the contingency was switched to the complex FCR2. Stable rates of the complex FCR2 were subsequently observed ($M$ = 1.4 RPM, $SD$ = 0), and rates of the complex FCR1 were reduced to zero while problem behavior and the simple FCR remained at zero. Thus, when and only when the reinforcement contingency supported a response did we observe elevated rates of the target response, while responses that were reinforced only in the preceding phase decreased, and responses that were not reinforced in the current or preceding phase remained at zero. When reinforcement thinning was introduced, John began emitting the tolerance response ($M$ = 1 RPM, $SD$ = 0.35) along with the complex FCR2 ($M$ = 1.2 RPM, $SD$ = 0.2). As instructions were

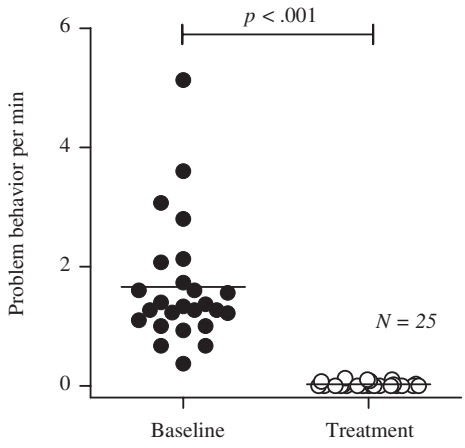


Figure 3. Mean rate of problem behavior (horizontal line) before (final three baseline) and after (final three treatment) the introduction of treatment. Each symbol represents one of the 25 consecutive participants. Statistical significance determined by the two-tailed Wilcoxon signed-rank test ($Z$ = -4.37, $p$ < .001).

presented, the variability of his problem behavior increased, but the mean rate remained low ($M$ = 0.08 RPM, $SD$ = 0.15) and compliance was high ($M$ = 98.4%, $SD$ = 1.87).

Six participants experienced the DRO-based reinforcement thinning procedures, and the terminal requirement ranged from 30 s to 900 s for these participants. Figure 5 shows an example of a participant who experienced the DRO-based reinforcement thinning procedures. Joe's problem behavior was on an increasing trend during the baseline phase ($M$ = 0.6 RPM, $SD$ = 0.22). When FCT was initiated, his problem behavior was eliminated, and the simple FCR increased ($M$ = 1.53 RPM, $SD$ = 0.21). Elevated rates of the complex FCR were observed ($M$ = 1.77 RPM, $SD$ = 0.06) during the final phase of FCT while problem behavior remained at zero and the simple FCR was no longer emitted. Following the baseline condition, we observed increased rates of the FCRs only when the reinforcers were presented contingent on each. In addition, the complexity of the FCRs increased with the increase in the set criteria. When reinforcement thinning began, the reinforcers were presented 50% of the time contingent on the complex FCR and tolerance responses. This resulted in elevated rates of the tolerance response ($M$ = 0.93 RPM, $SD$ = 0.23), and low and stable rates of complex FCRs ($M$ = 0.77 RPM, $SD$ = 0.15). Delays were introduced after Joe acquired the tolerance response. The duration of reinforcer access was gradually decreased, and time without access to reinforcement was gradually increased as problem behavior remained low ($M$ = 0.05 RPM, $SD$ = 0.08). By the final thinning level, time without reinforcement was 16.75 min out of a 20 min session.

The remaining participants experienced a combination of DRA- and DRO-based reinforcement thinning procedures. Figure 6 represents the treatment process for Kane. An increasing trend in problem behavior was observed during the baseline phase ($M$ = 0.56 RPM, $SD$ = 0.46). However, Kane's problem behavior was eliminated during FCT when he was taught the simple FCR ($M$ = 1.4 RPM, $SD$ = 0.2). The rate of the simple FCRs dropped to zero when the contingency was shifted to the complex FCR ($M$ = 1.53 RPM, $SD$ = 0.12). The rate of problem behavior remained at zero. The complex FCR continued to occur at elevated rates ($M$ = 1.27 RPM, $SD$ = 0.12) after the tolerance response ($M$ = 0.8 RPM, $SD$ = 0) was added to the contingency, rates of problem behavior remained at zero, while simple FCRs occurred infrequently ($M$ = 0.13 RPM, $SD$ = 12). Throughout FCT, Kane's problem behavior was reduced in comparison to the baseline condition, and increasingly complex FCRs were observed when reinforcement was contingent on them. DRA-based reinforcement thinning was first introduced to increase Kane's compliance with simple instructions and transition-based demands (e.g., "stand up," "hold hands," "walk to [area]," "sit in chair") because his problem behavior was sensitive to escape from transitions which involved losing access to preferred items. As the number of instructions was progressively

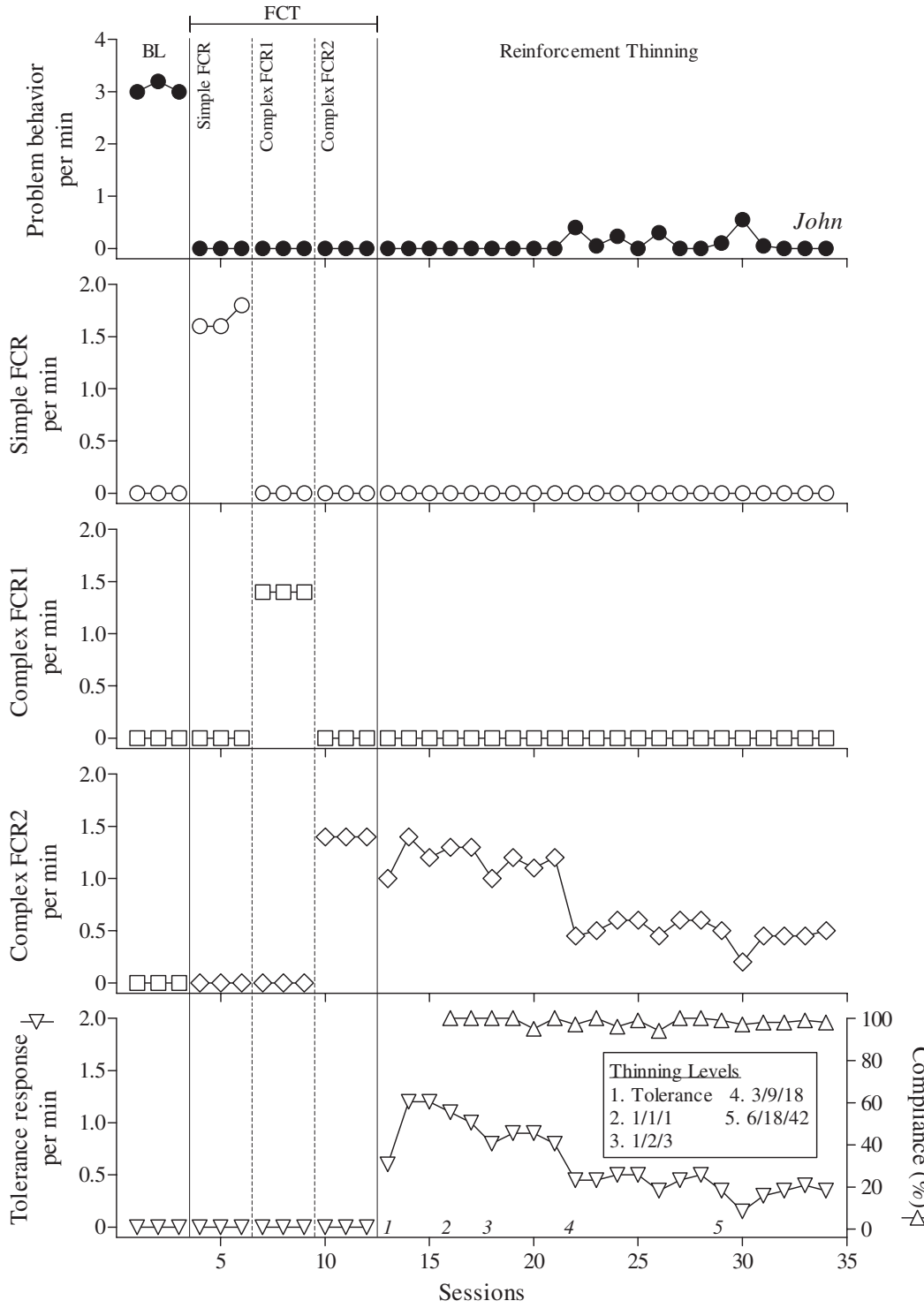


Figure 4. Treatment evaluation for John who experienced the DRA-based reinforcement thinning procedures. The values in the thinning levels refer to the easy/moderate/difficult set of instructions. For example, in level 5 schedule thinning, John was asked to complete 6 instructions, 18 instructions, or 42 instructions with equal probability during a session.

increased, Kane's rates of problem behavior remained low, with the exception of a burst during the first session in which he was presented with instructions. When Kane reached 24 instructions in the trial with the highest difficulty, the DRO-based reinforcement thinning procedure was added to his treatment package. Instructions to transition away from his toys to different areas of the building were introduced. Kane had to walk with the therapist for the entirety of the interval without problem behavior to avoid resetting the required time interval. By the final thinning level, Kane's rates of problem behavior remained low ($M$ = 0.02, $SD$ = 0.02), percentage of compliance remained high ($M$ = 98.7%, $SD$ = 0.47), and he was experiencing an 11.93-min mean delay without reinforcement in a 20-min session.

The mean percentage of session time without reinforcement during the final reinforcement thinning level across all the participants is presented in Figure 7. Although no duration requirement was in place for participants who experienced the DRA-based reinforcement thinning procedures, an average of 51% of the session was spent without reinforcement. This was more than three times the duration during the initial level of FCT.

The results of the pre- and post-ratings of caregiver concerns are presented in Figure 8. Caregivers rated many situations and behaviors as major concerns prior to the onset of the assessment and treatment process ($M$ = 12.9, $SD$ = 6.4). When the same measure was obtained following the assessment and treatment process, there was a 76% decrease in the number of major concerns ($M$ = 3.1, $SD$ = 3.4). Inversely, a 74% increase was observed in the number of situations or behaviors that were not considered a concern before ($M$ = 13.0, $SD$ = 6.1) and after ($M$ = 22.7, $SD$ = 8.7) the clinical services.

Caregivers' acceptance of the treatment and satisfaction with the improvement observed in their child's behavior is presented in Figure 9. The majority of caregivers found the treatment highly acceptable ($M$ = 6.8, $SD$ = 0.5), with only two caregivers scoring the treatment lower than 7 out of 7. In addition, most of the caregivers were satisfied with the overall amount of improvement seen in their child's problem behavior ($M$ = 6.5, $SD$ = 0.7) and communication skills ($M$ = 6.3, $SD$ = 0.8). Lastly, parents also found the treatment to be very helpful with improving behavior in the home ($M$ = 6.9, $SD$ = 0.3).

We found FCT with contingency-based reinforcement thinning informed by an IISCA to be an effective treatment across 25 clinical cases. At least a 90% reduction in problem behavior was obtained across all participants within a 1-week period. These treatment procedures and improvements in problem behavior and appropriate communication were rated highly acceptable, satisfactory, and helpful by caregivers. These results show that function-based treatments informed by the IISCA are effective for treating severe problem behavior. The positive results of the assessment and treatment process were replicated with children and adolescents, with and without multiple diagnoses, and with a range of language abilities. Therefore, the current study extends the generality of the assessment *and* treatment processes based on the IISCA.

It is difficult to determine at what point during the reinforcement thinning process the schedule of reinforcement reaches a level that is sustainable in the classroom or home environment. Although most of the participants reached a terminal goal likely to be acceptable following their participation, some were able to reach a treatment schedule of only modest delay. For example, Anton's terminal delay interval was 30 s. In the current model, participation was restricted to a fixed duration of 2 weeks, and some participants may have required more time to reach larger delay intervals. In such cases, we provided information to the parents during parent training on (a) the

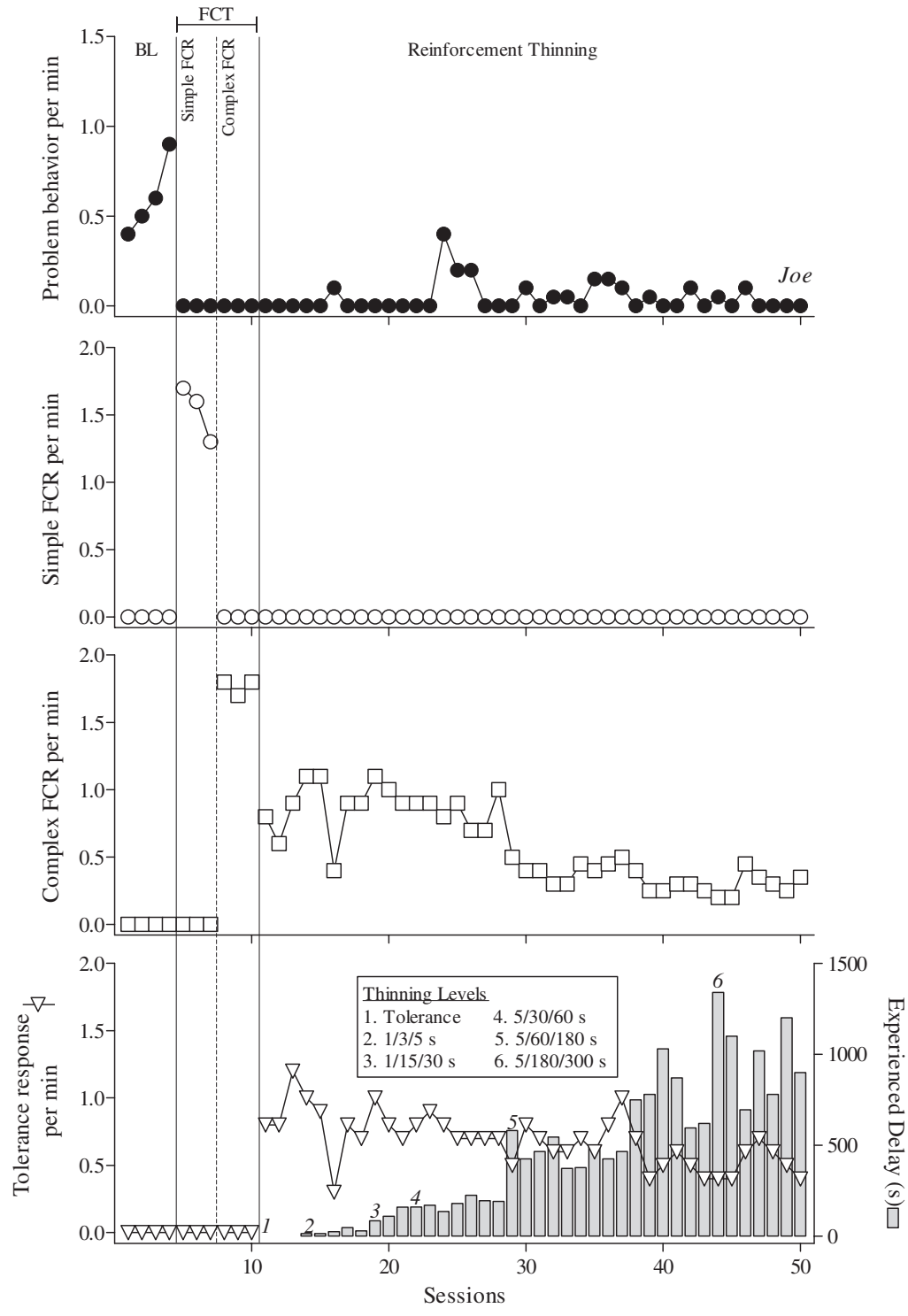


Figure 5. Treatment evaluation for Joe who experienced the DRO-based reinforcement thinning procedures. The values in the thinning levels represent the easy/moderate/difficult delay intervals. For example, in level 6 schedule thinning, Joe was told to wait for 5 s, 180 s, or 300 s with equal probability during a session.

rationale and goals of reinforcement thinning, (b) the procedures and criteria we used to thin reinforcement, and (c) indicators of when it is safe to thin the schedule of reinforcement or when to return to an earlier schedule requirement. Nevertheless, future research should be conducted on evaluating procedures for transferring these treatments to caregivers and to homes and classrooms.

Although the brief time required to achieve these socially validated effects may be considered a strength of the study, it may not be feasible for practitioners to devote 7 hr per day, 5 days per week to one patient. Hanley et al. (2014) achieved similar outcomes with three participants diagnosed with ASD in 22 to 32 ($M$ = 27) 1-hr outpatient and home consultations, which lasted a total of 8 to 14 ($M$ = 11.3) weeks. Thus, the results obtained are more likely to be due to the effectiveness of the IISCA and treatment processes than the particular distribution of the intervention process. Practitioners may be able to choose the schedule that best fits their situation, knowing that between 20 and 35 hours of therapy will probably be needed for an effective outcome.

To better understand how the current results relate to other function-based treatment outcome studies, we compared the results and the processes to achieve them in the current study to three other outcome studies (see Figure 10). No supplemental procedures (i.e., punishment, alternative reinforcement) were required to achieve satisfactory outcomes for the 25 participants in the current study. Most of the applications (22 of 25) in Greer et al. (2016) also did not require supplemental procedures. By contrast, approximately 50% of the applications in Hagopian et al. (1998) and Rooker et al. (2013) that involved FCT and reinforcement thinning required the addition of supplemental procedures. We then compared the percentage of cases resulting in at least 80-, 90-, or 95% reductions in problem behavior across the four studies (Figure 10; reductions were assessed prior to schedule thinning [top panel], and following schedule thinning [bottom panel]). The current study had the highest percentage of applications with ≥ 80% reductions in problem behavior, followed by Greer et al. (2016), Rooker et al. (2013), and Hagopian et al. (1998). The same pattern was observed when considering the reductions following reinforcement thinning (bottom panel), with the exception that Hagopian et al. had slightly more applications with ≥ 95% reductions in problem behavior compared to Rooker et al.

The current study differed from the previous outcome studies in multiple ways; therefore, it is difficult to determine what contributed to the comparatively better outcomes from this study. Improved treatment outcomes could be accounted for by considering evaluation criteria. Many studies have used a more conservative measure (e.g., final five sessions instead of final three) when calculating the percentage reduction in problem behavior from baseline to treatment. There is precedence for including three sessions (Wacker et al., 1998), and in the current study, this measure was chosen for practical reasons, because the IISCA often only included three sessions in the test condition. Nevertheless, these differing criteria may affect differences across outcome studies. It is possible that the participant samples differed in fundamental ways, and that these differences may account for the differences in outcomes. It is also possible and just as plausible that the differences in the assessment and treatment procedures were responsible for the observed differences.

Regarding assessment, the functional analysis procedures for all of the previous outcome studies were identical and cited the standard format from Iwata et al. (1982/1994). We conducted a particular type of functional analysis, and IISCA, that differed from the standard functional analysis format, and this change could have resulted in improved treatment

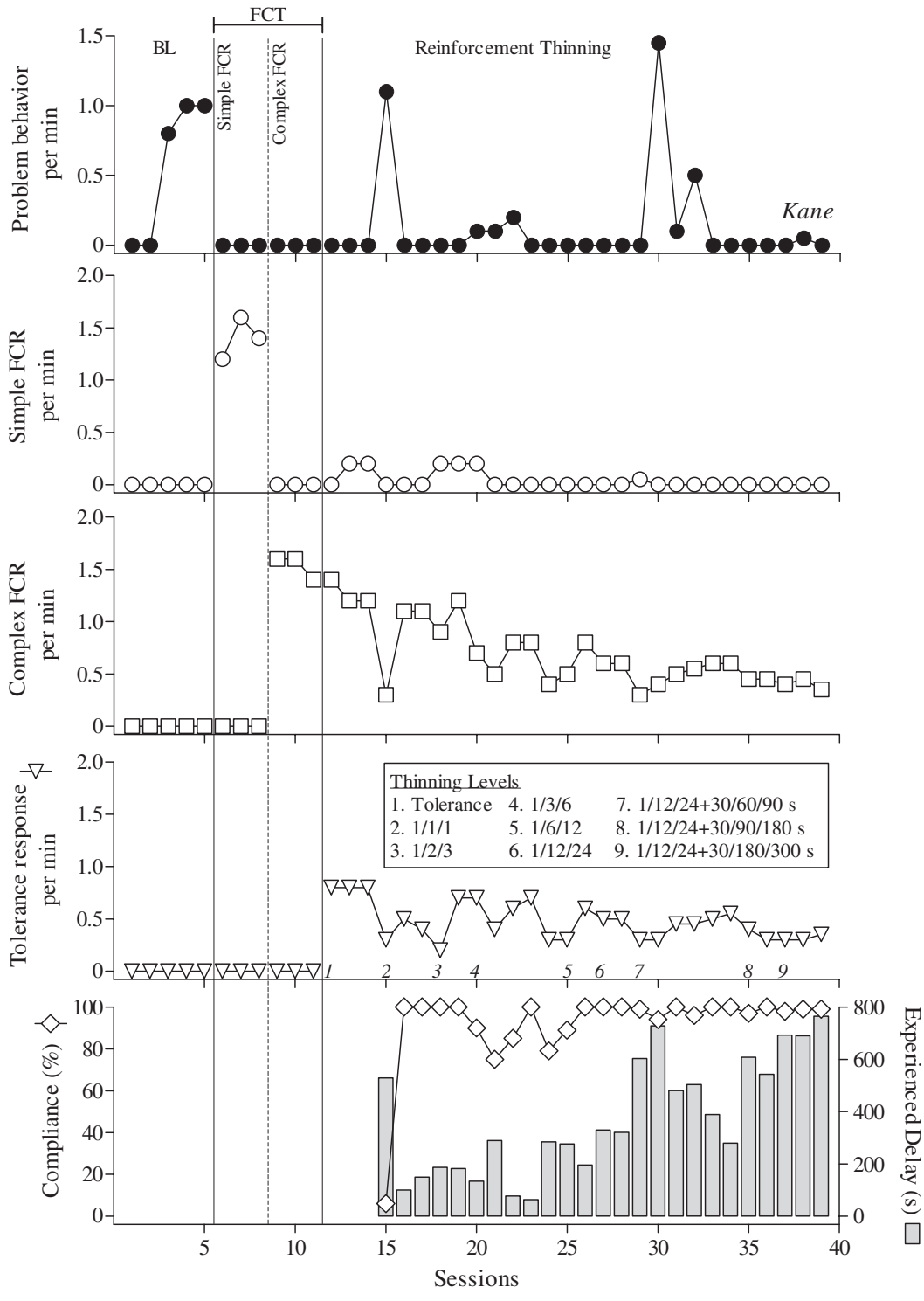


Figure 6. Treatment evaluation for Kane who experienced both the DRA- and DRO-based reinforcement thinning procedures. The values in the thinning levels represent the easy/moderate/difficult set of instructions and the easy/moderate/difficult delay intervals. For example, in level 9 schedule thinning, Kane was asked to complete 1 instruction, 12 instructions, or 24 instructions and asked to wait for 30 s, 180 s, and 300 s with equal probability during a session.

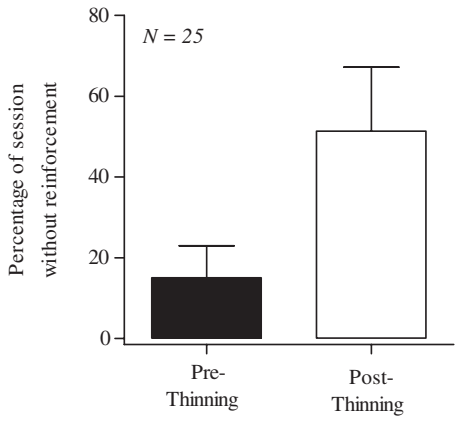


Figure 7. Mean percentage of session without reinforcement before and after the introduction of reinforcement thinning. Pre-thinning refers to the mean of the FCT sessions before tolerance was introduced. Post-thinning refers to the mean of the sessions of the final reinforcement thinning level.

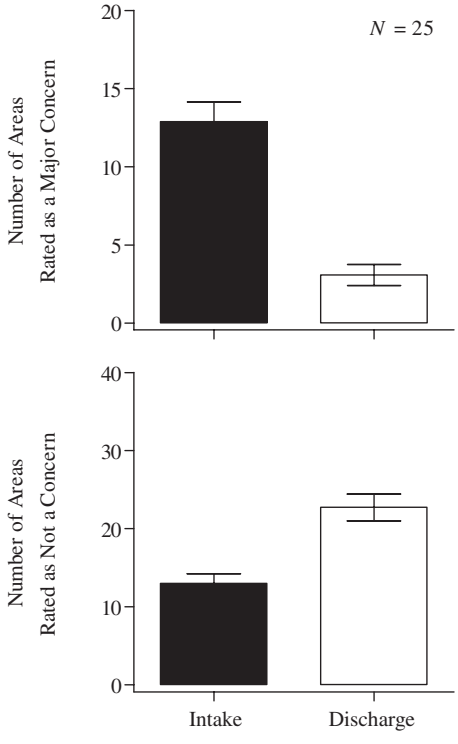


Figure 8. The mean number of settings and behaviors rated as major concerns (top panel) and not a concern (bottom panel) before and after the patients' participation. Error bars represent standard error measurement (SEM).

effects. Some support for this comes from Slaton et al. (2017) who observed better treatment outcomes from the IISCA than from a standard analysis for participants who experienced both. The critical differences are probably those tacted in the name of the analysis—the inclusion of personalized reinforcement contingencies that are informed from an interview and the synthesis of those contingencies into a single context that is used as the basis for teaching skills. Regarding treatment, all participants were exposed to contingency-based reinforcement thinning procedures in the current study. In contrast, previous studies often included time-based thinning (e.g., Hagopian et al., 1998) or multiple schedules during reinforcement thinning (e.g., Greer et al., 2016). In a within-subject comparison of variations in time-based delays and contingency-based reinforcement thinning, Ghaemmaghami et al. (2016) found contingency-based procedures to result in greater reductions in problem behavior, reduced likelihood of collateral responding (e.g., excessive manding), and increases in experienced delays to reinforcement with four participants. In the context of treating automatically reinforced stereotypy, Slaton and Hanley (2016) recently showed that strong stimulus control over appropriate and problem behavior was not achieved with multiple schedules but was achieved with chained schedules for the same participants (participants also preferred the chained schedule over the multiple schedule). Of course, the functional analysis procedures and the contingency-based thinning may have interacted to produce improved outcomes.

There were other procedural differences between the current and previous studies that may have enhanced treatment outcomes. For example, the participants were taught multiple forms of communication of increasing complexity in the current study. Besides the social and developmental appropriateness of teaching children multiple ways of communicating,

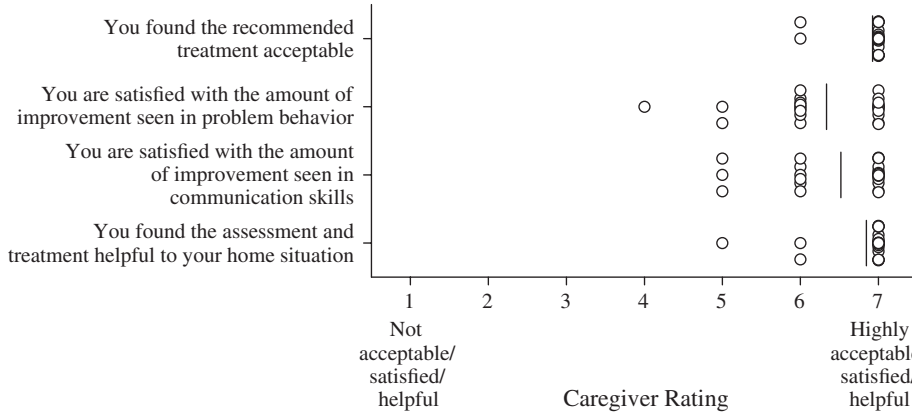


Figure 9. Each symbol represents an individual rating by a caregiver. The mean caregiver ratings (vertical line) of treatment acceptability, performance improvement, and helpfulness.

teaching multiple and more complex FCRs may have therapeutic value as well. In a translational evaluation, Lambert, Bloom, Samaha, Dayton, and Rodewald (2015) taught three adults with developmental disabilities to emit arbitrary responses using traditional DRA or with serial alternative response training. The serial alternative response training involved sequentially reinforcing and extinguishing three different alternative responses. When all behavior was placed on extinction, Lambert et al. (2015) found that the target response was more likely to resurge in the traditional DRA condition in which only one response was taught. Our arrangement was similar in that we sequentially taught different mands of increasing complexity while placing the previous forms on extinction.

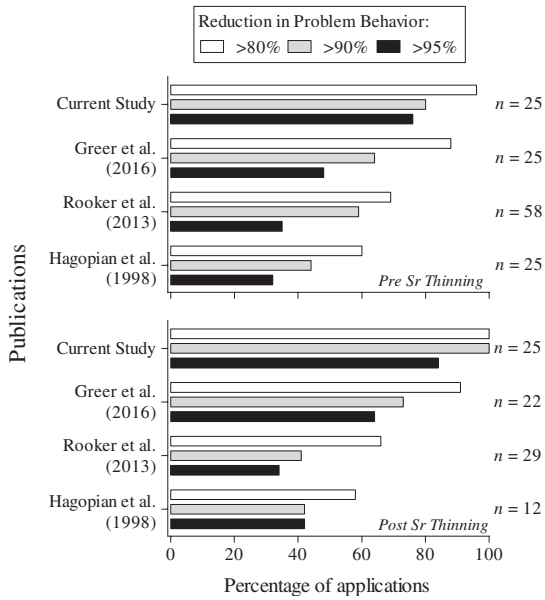


Figure 10. Percentage of applications in each outcome study with greater than 80% (white), 90% (gray), and 95% (black) reductions in problem behavior before (top panel) and after reinforcement thinning (bottom panel). Only applications that involved FCT with extinction and no supplemental procedures were included in this comparison.

## GENERAL DISCUSSION

We found that the IISCA enabled us to address the core objectives of a functional analysis (Hanley, 2012). The IISCA established an understanding of problem behavior by identifying socially mediated variables maintaining problem behavior with 25 patients. The IISCA test condition served as an appropriate baseline for subsequent treatment evaluations, and the reinforcement contingencies from the IISCA provided a highly motivating instructional context, as shown by the successful replacement of

problem behavior with multiple forms of socially appropriate communication responses of increasing complexity. Perhaps most important was that we observed large reductions in problem behavior across all participants by the end of reinforcement thinning. In other words, this study illustrates both what is possible as well as what is probable when an IISCA is used to develop FCT and contingency-based schedule thinning procedures to treat severe problem behavior.

The results of Study 1 directly replicate the IISCAs from Jessel et al. (2016) and Slaton et al. (2017) in that all were efficient, with the majority being conducted in 30 min or less. In a recent survey of 700 practicing behavior analysts, Oliver et al. (2015) found that 63% reported never or almost never using a functional analysis. The views of 205 practitioners in Massachusetts mirrored this sentiment, when a majority of them reported choosing descriptive assessment over functional analyses (Roscoe et al., 2015). Thus, practitioners are choosing efficient assessments in the absence of analysis even though they are known to be unreliable (Iwata et al., 2013) and of uncertain treatment utility (Hanley, 2012). Follow-up surveys in 5 to 10 years will help to determine if preferences for assessments change with the introduction of more efficient and valid functional analysis formats, like the IISCA.

Despite the experimental imprecision of the IISCA, we found in Study 2 that the IISCA allowed for effective and socially valid treatment outcomes. In fact, IISCA-informed treatments seemed to result in improved treatment effects in comparison to other formats. In the outcome study by Greer et al. (2016), supplemental procedures using arbitrary reinforcement were required in 20% of the applications of FCT during reinforcement thinning. Rooker et al. (2013) found similar results, with 23% of applications requiring supplemental reinforcement or punishment procedures when FCT alone failed to reduce problem behavior. None of the patients in the current study required supplemental treatment procedures, and the reductions in problem behavior were achieved using only the reinforcers identified via the IISCA. However, more single-subject comparisons of treatments informed by each functional analysis format, like that modeled by Slaton et al. (2017) are needed. As of now, the IISCA has sufficient evidence to support its utility in developing an effective function-based treatment in the same time it would take to conduct a typical 30-60 min indirect assessment. The IISCA provides an empirical demonstration of functional control over problem behavior, a baseline from which to evaluate treatment, and a motivating context to shape appropriate behavior, whereas an indirect assessment of equal duration provides none of these. Thus, we argue that the concern that a functional analysis requires too much time is no longer relevant. An IISCA is time-efficient and has demonstrated utility for designing treatments. Practitioners can therefore remain committed to an empirical and analytic understanding of problem behavior prior to its treatment.

It should also be recognized that ecological validity was strong throughout the assessment and treatment process, because caregivers provided the qualitatively rich information guiding analysis and treatment decisions. A specific problematic context occasioning problem behavior in the home or school was arranged in the test condition of the functional analysis. In addition, the participants were taught to comply with tasks or engage in alternative activities nominated by caregivers as areas of concern when functional reinforcers were not available. Structuring the assessment and treatment context to fit the environment specified by the caregivers may reduce the effort of treatment implementation in other contexts. For example, there are no additional reinforcers, punishers, or materials needed (e.g., red/green boards signaling when reinforcement is available) given

that the interactions in treatment are similar to those that were occurring on a daily basis with the important exception being the timing of the delivery of the synthesized reinforcers. Nevertheless, measurement of caregiver treatment fidelity during training and evaluations of adherence to the procedures following discharge are necessary in future work.

In addition, social validity measures should continue following discharge, and multiple global outcomes such as IQ, classroom performance, adaptive functioning, and quality of life should be measured following discharge to determine the broader effects treatment of problem behavior may have for the patient and his or her family.

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*Received September 29, 2016*
*Final acceptance December 18, 2017*
*Action Editor, John Borrero*

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