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INTERVIEW-INFORMED SYNTHESIZED CONTINGENCY ANALYSES: THIRTY REPLICATIONS AND REANALYSIS

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The speed with which a functional analysis (FA) provides a convincing demonstration of the variables that influence problem behavior may be termed *efficiency*. Multiple FA formats have been developed to improve analytic efficiency while the core components of the Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) procedures are maintained. We attempted to illustrate an alternative efficient process for conducting FAs of problem behavior that relied on modifying those core components. In Study 1, we describe 30 applications of the interview-informed synthesized contingency analysis (Hanley, Jin, Vanselow, & Hanratty, 2014), which required an average of 25 min of analysis. The first sessions of these analyses were reanalyzed in Study 2 to determine if contingencies that controlled problem behavior could be identified in only 3 to 5 min. This was the case in 80% of analyses.

Key words: brief analysis, efficiency, experimental control, functional analysis, interview-informed analysis, synthesized contingency analysis, within-session analysis

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The term *functional analysis* (FA), in the field of behavior analysis, refers to an empirical demonstration of a functional (cause-and-effect) relation between behavior and specified environmental variables (Baer, Wolf, & Risley, 1968). The most basic components of an FA of problem behavior are (a) a test condition in which the hypothesized reinforcer is provided contingent on problem behavior, (b) a control condition in which the response–reinforcer contingency is absent, and (c) the use of a single-subject experimental design (Hanley, Iwata, & McCord, 2003). Reliable control of problem behavior via systematic manipulation of specific antecedents, consequences, or both is the immediate goal of an FA, with the ultimate goal being the development of an effective and socially valid treatment for problem behavior.

Differentiated results from an FA, in which problem behavior is reliably observed to occur more in test sessions than in control sessions, imply that adequate control of problem behavior has been demonstrated by a suspected contingency and that a function-based treatment can be developed with confidence. Results of FA reviews by Hanley et al. (2003) and Beavers, Iwata, and Lerman (2013) show that 94% of published FAs have yielded differentiated results. The speed with which control is demonstrated is an important factor to consider. Conducting an FA of problem behavior requires time and resources, both of which are

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typically limited for practicing behavior analysts. Furthermore, the longer it takes to identify the determinants of problem behavior, the longer treatment is delayed. Fewer FA sessions would also presumably result in fewer chances for injury to occur to the child or the implementer of the FA. Thus, it is important to consider both the effectiveness of the analysis to demonstrate control by the suspected reinforcement contingency and the efficiency of the process.

Multiple tactics aimed at achieving analytic efficiency have been described and include reducing the number of sessions per condition (Derby et al., 1997; Kahng & Iwata, 1999; Northup et al., 1991), the number of minutes per session (Wallace & Iwata, 1999), the number of trials per session (i.e., number of presentations of the putative establishing operations [EOs]; Bloom, Iwata, Fritz, Roscoe, & Carreau, 2011; Bloom, Lambert, Dayton, & Samaha, 2013; Sigafoos & Saggers, 1995), or changing the measure from rate to latency, and by so doing, essentially reducing the number of trials per session (Thomason-Sassi, Iwata, Neidert, & Roscoe, 2011). These tactics reduced the time required to conduct a traditional FA as described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) by 67% to 95%.

The core procedural components of the Iwata et al. (1982/1994) FA were maintained in the efficiency-based formats noted above; these components are (a) multiple test conditions that assess sensitivity to social-positive and social-negative reinforcement, (b) uniform procedures across participants within each distinct test condition to test for common contingencies, (c) the isolation of possible controlling contingencies in distinct test conditions, and (d) comparison of the test contingencies to an omnibus control condition (referred to as the play condition) that serves as a control for all test conditions.

Several studies have provided independent support for modification of each of these components to create differentiated analyses. Hanley, Iwata, and Thompson (2001) provided an example of a modification to the first component (multiple test conditions). Instead of implementing an analysis with multiple test conditions, staff members were interviewed before the analyses for each of the three participants and the putative reinforcers were presented contingent on problem behavior during a single test condition. These single test–control analyses permitted the effective design and implementation of function-based treatments.

DeLeon, Kahng, Rodriguez-Catter, Sveinsdóttir, and Sadler (2003) retained multiple test conditions; however, they modified the uniformity of the test conditions. Following informal observations, these authors hypothesized that the participant's aggression may have been functioning to provide movement when he was seated in his wheelchair. An additional test condition was then included in which the participant's wheelchair was moved contingent on aggression.

The isolated test conditions component has also been modified by simultaneously assessing two or more contingencies in a single test condition. For instance, Hagopian, Bruzek, Bowman, and Jennett (2007) conducted what was termed an *interruption analysis* on the problem behavior of two boys with intellectual disabilities. After 30 s of free access to preferred activities during the test condition, the participants were interrupted and prompted to exhibit behavior that was incompatible with the current activity (e.g., if they were sitting they were asked to stand). Problem behavior resulted in the simultaneous delivery of positive and negative reinforcement: the termination of prompts to engage in incompatible tasks and the returned access to preferred activities. Although both were tested in isolation during a previous functional analysis with procedures identical to that described by Iwata et al. (1982/1994), differentiation was not observed until the contingencies were synthesized in a subsequent analysis.

Control conditions other than play have been included in FAs that appear to offer a more precise match between test and control conditions. For example, the only difference between the control and test conditions in the analyses in Hanley et al. (2001) was whether the putative reinforcer was provided contingently or noncontingently. More specifically, the reinforcer was provided contingent on problem behavior in the test condition but was provided noncontingently during the control condition, and no other feature of the analytic context changed across conditions (i.e., the implementer, type of toys, amount or quality of attention, presence or absence of demands, etc., were the same across test and control sessions). Bowman, Fisher, Thompson, and Piazza (1997) also modified the play control in an FA related to adult compliance with children's requests. The implementer either complied with the participant's requests for 30 s following problem behavior (test condition) or complied independent of problem behavior (control condition). Thus, the procedures of the two conditions were identical, with the exception of the contingency.

Modifications to each of the four analysis components have allowed differentiated FA results in the above studies as well as others (e.g., Adelinis & Hagopian, 1999; Broussard & Northup, 1997; Brown et al., 2000; Buchanan & Fisher, 2002; Derby et al., 1997; Fisher, Kuhn, & Thompson, 1998; Horner & Day, 1991; Jones, Drew, & Weber, 2000; Kuhn, Hardesty, & Luczynski, 2009; Lalli, Casey, & Kates, 1995; Lambert, Bloom, & Irvin, 2012; Lerman & Iwata, 1993; Peck et al., 1996; Ringdahl, Winborn, Andelman, & Kitsukawa, 2002; Wilder, Harris, Reagan, & Rasey, 2007; Worsdell, Iwata, Hanley, Thompson, & Kahng, 2000; Yarbrough & Carr, 2000). The modifications were usually prescribed as additions to the Iwata et al. (1982/1994) procedures (e.g., DeLeon et al., 2003) or were programmed following inconclusive results of those procedures (e.g., Bowman et al., 1997; Fisher, Adelinis, Thompson, Worsdell, & Zarcone, 1998). In a review of the various components found in the more general functional assessment process, Hanley (2012) suggested that these modifications to analyses be incorporated into initial FAs. Hanley, Jin, Vanselow, and Hanratty (2014) followed with empirical examples in which these four procedural modifications were simultaneously incorporated into the initial FAs of the problem behavior of three children with autism. Instead of multiple, uniform, and isolated test conditions, the analysis for each participant included only one individualized and synthesized test condition per control that matched the test condition with the exception of the contingency (all putative reinforcers were provided continuously). By designing each child's analysis from the results of open-ended interviews, individualized analyses were implemented with each child and were completed in an average of 23 min. Although no formal title for the specific FA format was given by Hanley et al., it has since been referred to as an interview-informed synthesized contingency analysis or IISCA (see www.practicalfunctionalassessment.org).

The IISCA approach yielded control of problem behavior quickly by reducing the overall number of conditions and by incorporating all idiosyncratic variables suspected of influencing problem behavior into the analysis. However, this analysis format was implemented with only three children; additional replications are needed to determine the utility of this format. Our specific aims in the current paper are to describe additional outcomes from the IISCA approach introduced by Hanley et al. (2014) and to determine the extent to which the time required to conduct the IISCA can be reduced while the experimental integrity of the FA is maintained.

STUDY 1: REPLICATIONS OF THE IISCA

Method

Participants and settings. Parents or program administrators reported that all participants regularly engaged in severe problem behavior. A single analysis was implemented with 24 participants. Two analyses were conducted with three participants because there were two distinct contexts associated with problem behavior. From this, 30 total analyses are reported. Characteristics of participants who experienced the IISCA are presented in Table 1. Participants ranged in age from 1.8 to 30 years old, with a median age of 7 years. There were 24 males and 3 females. Of the 26 participants, 21 had been diagnosed with autism. Two participants had been diagnosed with pervasive developmental disorder, two had no formal diagnosis, one had been diagnosed with attention deficit hyperactivity disorder (ADHD), and another had multiple diagnoses of ASD, ADHD, and generalized anxiety disorder (GAD). In addition, participants' language abilities were categorized from record review and direct observations on a scale from 1 (nonverbal) to 4 (full fluent sentences). The median language ability was short disfluent sentences; however, the entire language spectrum was represented in our sample.

Table 1 (right) shows characteristics of the analysis implementer. The implementers were caregivers, trained tutors employed by the outpatient clinic, students enrolled in masters or doctoral programs in behavior analysis, or a practicing behavior analyst with a doctorate. The majority of the FAs (24 of the 30) were conducted by a board certified behavior analyst (BCBA), with all other implementers being supervised by BCBAs. In addition, in 22 analyses, the implementer had direct experience as the lead in creating, conducting, and analyzing results of FAs. In the remaining eight analyses, the implementer had not previously conducted an FA.

Sessions lasted 3 to 15 min and were conducted at a university outpatient clinic for 10 of the 30 analyses (Table 2). The outpatient session rooms (3 m by 4 m) typically included a table and two chairs. Seven analyses were conducted in the participant's home with at least one caregiver present. Five analyses were conducted in a classroom with other students present in schools that provide specialized services for children with autism. Four analyses were conducted in an outpatient clinic. The clinic session room (3 m by 6 m) included a sitting area for family members to observe sessions openly, a table and chairs for tabletop activities or academics, and a play area with a soft mat. The analyses for Sam and Will were conducted in their day-program habilitation area with other clients present. Dan's analysis was conducted in a meeting room at his public school.

Measurement and interobserver agreement. Problem behavior included aggression (e.g., hitting, kicking, scratching, pinching), self-injury (e.g., head hitting with fist or open hand, head banging on objects, arm or finger biting), disruption (e.g., tearing, throwing, banging materials), and loud vocalizations (e.g., yelling, screaming). Loud vocalizations were included in the contingency class; however, they were typically identified by the caregivers during the interview as precursors to severe problem behavior. Rate of problem behavior was calculated by dividing the total number of responses within each session by the session duration. The duration of the reinforcement interval was also measured and began after the implementer had delivered all programmed reinforcers and ended when all reinforcers had been removed. Data were also recorded on the duration of each session, number of sessions, and number of times the procedures of the analysis had to be modified before differentiated results were observed. It was noted whether the analysis was primary (i.e., no modifications), secondary (i.e., an analysis with one modification), or tertiary

Table 1
Participant and Implementer Characteristics

	Participant characteristics					Implementer characteristics	
Participant	Age (years)	Gender	Diagnosis	Language ability[a]	Problem behavior	Credentials	First analysis (yes or no)
Alex (Context 1)	5	M	ASD	4	Aggression, disruption, loud vocalizations	BCBA	No
Alex (Context 2)	5	M	ASD	4	Aggression, disruption, loud vocalizations	BCBA	No
Jack (Context 1)	1.8	M	ASD	2	Aggression, disruption	Mother[b]	Yes
Jack (Context 2)	1.8	M	ASD	2	Aggression, disruption	BCBA	No
Kat (Context 1)	11	F	ASD	4	Aggression	BCBA	No
Kat (Context 2)	11	F	ASD	4	Aggression	BCBA	No
Kristy	4	F	ASD	1	Aggression, SIB	Tutor	No
Zeke	13	M	ASD	2	Aggression, loud vocalizations, SIB	Master's candidate	No
Dan	7	M	None	4	Aggression, disruption	BCBA	Yes
Roxy	6	F	ASD	3	Aggression, disruption, SIB	Tutor	No
Allen	7	M	ASD	1	Aggression, disruption, SIB	Tutor	No
Jim	3	M	ASD	2	Aggression, disruption, loud vocalizations, SIB	Tutor	Yes
Sam	24	M	ASD	2	Aggression, SIB	BCBA-D	No
Will	30	M	ASD	1	SIB	BCBA-D	No
Sid	9	M	ASD	4	Aggression, disruption	BCBA	No
Jeff	6	M	ASD, ADHD, GAD	4	Aggression, disruption, loud vocalizations, SIB	BCBA	No
Beck	17	M	PDD-NOS	3	Aggression, disruption, SIB	BCBA	No
Carson	14	M	ASD	4	Disruption, loud vocalizations	BCBA	No
Chris	11	M	ASD	4	Aggression, disruption, loud vocalizations	BCBA	Yes
Gary	2	M	ASD	2	Disruption, loud vocalizations	BCBA	Yes
Mike	5	M	ASD	2	Aggression, disruption, loud vocalizations, SIB	BCBA	Yes
Wayne	2	M	ASD	2	Disruption, loud vocalizations	BCBA	No
Earl	2	M	None	4	Loud vocalizations	BCBA	Yes
Jesse	12	M	ASD	3	Aggression, loud vocalizations, SIB	BCBA	No
Jian	4	M	ADHD	4	Aggression, disruption, loud vocalization	BCBA	No
Keo	2	M	ASD	2	Aggression, disruption, loud vocalizations, SIB	BCBA	No
Lee	17	M	ASD	1	Aggression, disruption, loud vocalizations, SIB	BCBA	No
Mitch	4	M	ASD	4	Aggression, disruption, loud vocalizations	BCBA	Yes
Paul	13	M	ASD	3	Aggression, loud vocalizations, SIB, disrobing	BCBA	No
Steve	20	M	PDD-NOS	3	Aggression, disruption, SIB	BCBA	No

[a]1 = nonverbal; 2 = one-word utterances; 3 = short disfluent sentences; 4 = full fluency.
[b]All analyses were conducted or supervised by a BCBA.

Table 2
Setting and Procedure Characteristics

Participant	Setting characteristics: Location	Setting characteristics: Analysis iteration	Procedure characteristics: Session duration (in minutes)	Procedure characteristics: Total analysis duration (in minutes)	Procedure characteristics: Synthesized contingency tested
Alex (Context 1)	University outpatient clinic	Tertiary (2)	3	15	Escape from teacher-directed to child-directed play with dinosaurs
Alex (Context t 2)	University outpatient clinic	Primary (1)	3	21	Escape from teacher-directed to child-directed drawing activity
Jack (Context 1)	University outpatient clinic	Secondary (1)	3	21	Access to social interaction and play time with mom and preferred items
Jack (Context 2)	University outpatient clinic	Primary (1)	3	18	Access to social interaction and play time with implementer and preferred items
Kat (Context 1)	Home	Primary (1)	5	25	Escape from teacher-directed to child-directed conversation topics
Kat (Context 2)	Home	Primary (1)	5	25	Access to unstructured play with iPad
Kristy	Outpatient clinic	Primary (1)	5	25	Escape from gross-motor instructions to preferred items
Zeke	Specialized school	Primary (1)	5	25	Escape from academic tasks to singing with implementer and access to preferred items
Dan	Public school	Primary (1)	3	18	Escape from writing task to social interaction and play time with implementer and preferred items
Roxy	Outpatient clinic	Primary (1)	4	20	Escape from social interactions
Allen	Outpatient clinic	Primary (1)	4	20	Escape from adult-directed activity to child-directed activity
Jim	Outpatient clinic	Primary (1)	5	25	Escape from physical prompting to preferred activities
Sam	Day habilitation	Primary (1)	3	15	Escape from vocational task to self-stimulatory materials
Will	Day habilitation	Primary (1)	3	18	Access to daily snacks
Sid	University outpatient clinic	Primary (1)	5	25	Escape from adult-directed activity to child-directed activity and preferred conversation
Jeff	University outpatient clinic	Primary (1)	5	25	Escape from teacher-directed activity to child-directed activity with high-quality attention from mom
Beck	Specialized school	Primary (1)	5	25	Escape from transitions to activities and preferred conversation
Carson	Home	Secondary (1)	10	50	Escape from life-skills tasks to activities
Chris	Specialized school	Primary (1)	3	15	Escape from academic task to preferred teacher with activities
Gary	University outpatient clinic	Primary (1)	3	15	Escape from academic tasks to activities with adult attention
Mike	University outpatient clinic	Primary (1)	3	15	Escape from adult-directed to child-directed activity
Wayne	University outpatient clinic	Secondary (1)	3	15	Escape from academic tasks to activities with adult attention
Earl	Home	Primary (1)	5	25	Escape from gross-motor tasks to activities with mother's attention
Jesse	Home	Primary (1)	5	25	Escape from adult-directed activity to child-directed activity
Jian	University outpatient clinic	Secondary (1)	3	15	Escape from academic tasks to child-directed activity and compliance with requests
Keo	Home	Primary (1)	3	18	Escape from academic tasks to activities with preferred teacher's attention
Lee	Specialized school	Secondary (5)	5	50	Escape from gross-motor tasks to edible items, activities, and adult attention
Mitch	Home	Secondary (1)	3	18	Escape from academic tasks to activities
Paul	Specialized school	Primary (1)	5	50	Escape from independent academic tasks and divided teacher attention to activities with teacher attention
Steve	Specialized school	Secondary (3)	15	75	Escape from academic tasks to activities with preferred conversation

Note. Analysis iteration refers to the number of modifications that were required before differentiated results were obtained. Numbers in parentheses refer to the number of visits each analysis required.

(i.e., an analysis with an additional modification).

Data were independently collected by students in a doctoral or master's program in behavior analysis, undergraduate assistants in a research course in applied behavior analysis, or staff at the habilitation centers or schools. Videos of sessions were recorded for half of the 30 analyses and were used to determine interobserver agreement. Interobserver agreement data were collected live by a second data collector for the other half of the analyses. Partial agreement coefficients were calculated for 23 analyses by dividing each session into 10-s intervals (or 30-s intervals for Will and Sam). The smaller number of responses recorded was divided by the larger number on an interval-by-interval basis, then converted to a percentage and averaged across intervals. For seven of the analyses, total agreement was calculated by dividing the smaller number of responses recorded in a session by the larger number recorded by each observer. Interobserver agreement data were collected for at least 29% of the sessions for all analyses (range, 29% to 100%), and mean agreement across participants ranged from 81% to 100% (range of session agreement scores was 75% to 100%).

Procedure

Open-ended interviews and observations. Every functional analysis was preceded by an interview conducted by an implementer with a caregiver. The questions were open ended and identical to those found in Hanley (2012). Questions were asked regarding the most problematic topographies of problem behavior, other problem behaviors that tend to co-occur or precede dangerous problem behaviors, and the possible antecedent and consequent events that should be incorporated into an analysis. The interviews took 30 to 90 min to complete across participants, with most interviews lasting 40 min. Observations (10 to 20 min) were then conducted during which implementers informally interacted with the participants. More information on the interviews and interactive observations can be found in Hanley et al. (2014).

Interview-informed synthesized contingency analyses. All analyses were specific to each participant and were conducted after the interview with the caregivers. Each analysis included one test (T) condition designed from the interview and one control (C) condition designed from the test condition; these conditions were alternated in a multielement design. Sessions were conducted in the format of CTCTT unless additional sessions were required to evaluate further the control by the suspected contingency. During the test condition, all putative reinforcers were simultaneously provided on a continuous reinforcement schedule for a fixed duration following any instance of the problem behaviors of greatest concern or any other problem behaviors that were reported to precede or co-occur with the more dangerous behaviors. The reinforcement interval was 30 s for the majority of the analyses. Kat (Context 1) and Will were the two exceptions. Kat (Context 1) was provided with 5 to 15 s of preferred conversation, whereas Will was given individual edible items after each instance of problem behavior. The participants were given noncontingent and continuous access to the same putative reinforcers in the control condition. (Additional information regarding the specific procedures for the FA for each participant is available in each of the primary articles listed in the Supporting Information or from the first author.) In other words, EOs were arranged for all reinforcers simultaneously during the test condition, and abolishing operations (AOs) were arranged for all reinforcers simultaneously during the control condition. Additional preferred items were not included in the control condition. The only difference between the test and control conditions was the presence or absence of the contingent delivery of the suspected reinforcers. In addition, general statements of concern (e.g., "don't do that," "you are hurting me") were not provided during test conditions when attention was indicated by caregiver assessments. Instead, the attention was specific to that which parents reported and matched that of the attention provided in the control condition. The assessment location, session duration, assessment duration, and specific contingencies assessed for each analysis are presented in Table 2. It is important to note that although some participants may have experienced similar analyses when considering the general classes of reinforcement (e.g., positive reinforcement in the form of implementer attention), the specific characteristics of those contingencies were unique to each individual (see Table 2).

Of the 30 analyses, 16 included a synthesis of different forms of positive reinforcement that included context-specific praise and attention during a period in which leisure items were available. Both negative and positive reinforcement contingencies were synthesized in 23 of the 30 analyses. In some cases, determination of the main effects of either positive or negative reinforcement was not possible. For example, the putative reinforcer for Kat's problem behavior during one context was escape from adult-directed to child-directed conversation topics. The EO involved the implementer conversing with Kat on topics she did not prefer (e.g., asking about the weather or how classes were going). The problem behavior would therefore result in both the removal of the implementer's conversation topics (negative reinforcement) and access to child-directed conversations about animals (positive reinforcement). In other analyses in which suspected positive and negative reinforcement were synthesized, the main effects of each reinforcing event could have been determined; however, the reinforcers were combined because they were reported to co-occur. For example, teachers reported that Zeke engaged in problem behavior during academic tasks and that they gave him their undivided attention and preferred toys to help him to calm down. The contingency arranged during the test condition for Zeke therefore included escape from academic demands to preferred activities and interactions with the implementer.

In all other analyses in which positive and negative reinforcement were synthesized, the reinforcer was specified by the participant. For example, similar to the analysis from Bowman et al. (1997), Alex's requests, which may have been for different negative reinforcers (e.g., break, alone time) or positive reinforcers (e.g., interactive or independent play), were honored for a period of time only after problem behavior.[1]

Results and Discussion

All FAs are presented in Figure 1. Across all analyses, high rates of problem behavior were observed during the test condition (M = 2.6 responses per minute), and low rates were observed during the control condition (M = 0.1 responses per minute). In fact, with the exception of Will, elevated rates of problem behavior were observed in the first test session for all participants. Furthermore, in 22 analyses, problem behavior did not occur in any control session. Nineteen analyses required the minimum number of five sessions (three test and two control sessions) to demonstrate control of problem behavior by the contingency and therefore to produce an adequate baseline for a treatment evaluation (i.e., stability across three test sessions). Seven analyses required six sessions, two analyses required seven sessions, and

[1]Almost half of these data sets were culled from different treatment-oriented studies, conducted under the supervision of the second author, that were in the process of being prepared or considered for publication at the time of this writing. Information on the original publications can be found in the Supporting Information. The other 16 FAs were developed from assessments that were conducted outside of formal research projects.

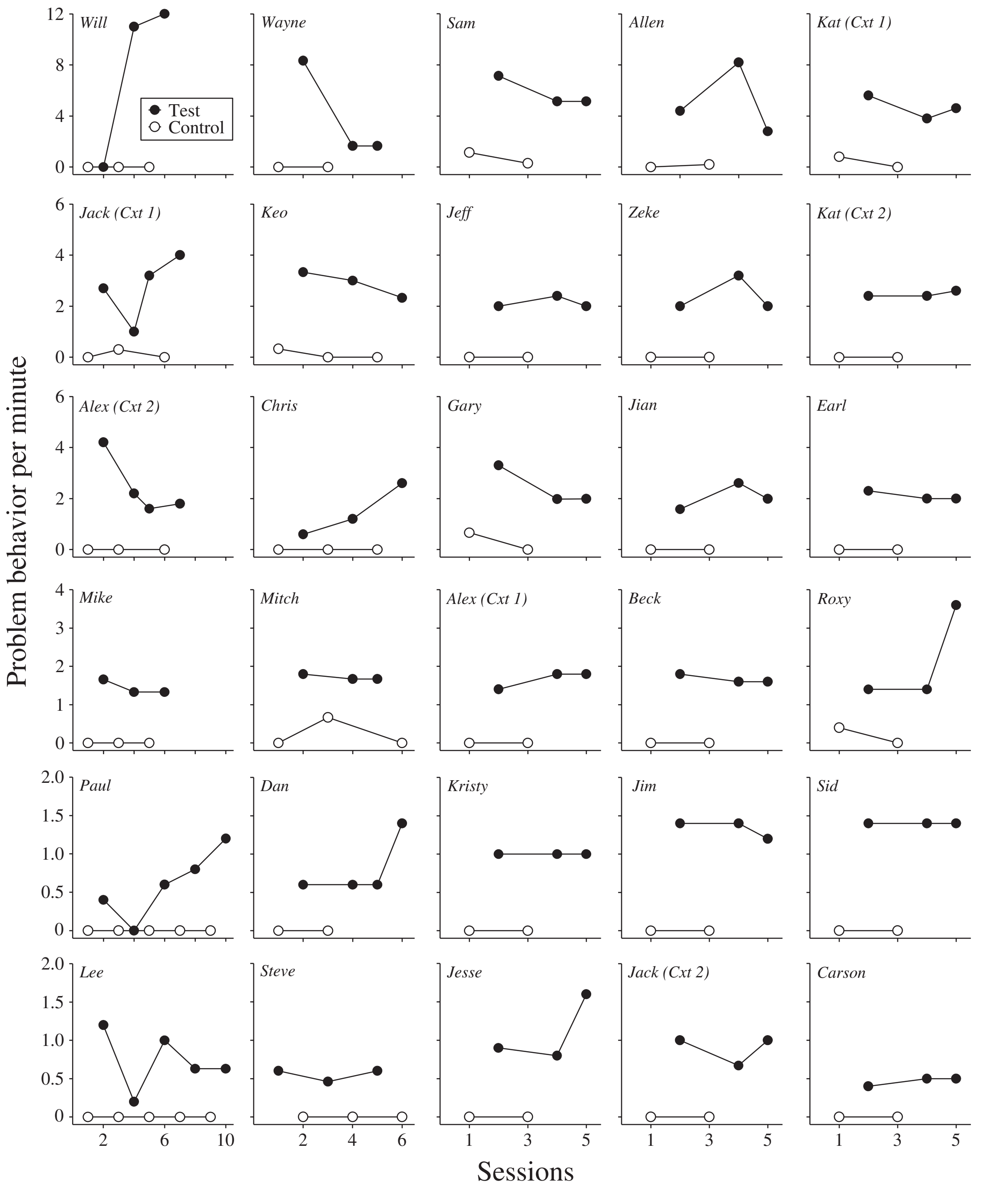

Figure 1. Thirty replications of the IISCAs.

the remaining two analyses required 10 sessions. The mean duration required to conduct an IISCA was 25 min (range, 15 to 75 min).

Table 2 lists the number of analysis iterations that were required before differentiated results were observed. The majority of the analyses required only the primary analysis conducted during a single visit with no modifications (22 of 30). Seven required a secondary analysis, and one required a tertiary analysis. As an example of modifications, the analysis with Alex required two modifications when no problem behavior was observed during a primary analysis that included attention and tangible items (primary iteration) and escape, attention, and tangible items (secondary iteration). Differentiated results were not observed until a synthesized contingency included compliance to requests (tertiary iteration). Even with the inclusion of multiple iterations, the majority of the analyses (27 of 30) required only one 1-hr visit.

For the final iteration, which was the first in 22 of 30 analyses, the IISCA resulted in immediate differentiation with almost exclusive responding in the test condition, which may be related to several factors. First, the possibility of carryover effects across conditions was reduced because there were only two rapidly alternating conditions (Iwata, Duncan, Zarcone, Lerman, & Shore, 1994; Vollmer, Marcus, Ringdahl, & Roane, 1995). A second factor was that continuous reinforcement was available during the control condition and may have served as a strong AO for problem behavior. This is compared to other control conditions in which there is a fixed-time delivery of reinforcers during the play condition (either with or without a brief period in which behavior has to be absent), which may evoke problem behavior or may inadvertently allow adventitious reinforcement (Vollmer, Ringdahl, Roane, & Marcus, 1997).

Third, the current analyses incorporated all of the implicated reinforcers in the control condition. If the reinforcers provided during the control condition were identical to those delivered contingent on problem behavior, there would be no EO to evoke any behavior in the operant class. However, if the reinforcers provided during the control condition were unrelated to those delivered contingent on problem behavior in the test condition, the process of satiation for the preferred items would inversely affect the motivation to exhibit problem behavior (DeLeon, Williams, Gregory, & Hagopian, 2005). In other words, as the value of the leisure activities decreases with extended exposure during the play condition, the value of the maintaining reinforcers may increase, which will concomitantly increase the probability of problem behavior in the control condition. Therefore, the stimuli in the control condition of the FA should probably not be included to compete with the reinforcers related to problem behavior (McCord & Neef, 2005) but, instead, should be identical to those reinforcers. Inclusion of stimuli intended to compete with the reinforcers raises questions as to variables that control differentiated responding apart from the suspected reinforcement contingency. In essence, control during the IISCA was not obtained by suppressing problem behavior by any means. Instead, control was obtained by eliminating problem behavior through the same means with which it was strengthened. Immediate and sustained elimination of problem behavior during the control condition was observed in the current analyses, possibly because of the continuous availability of all putative reinforcers that controlled problem behavior.

Fourth, all EOs related to different reinforcers that were reported to co-occur were arranged in the test condition and abolished in the control condition when the contingencies were synthesized. If the contingencies were separated into isolated test conditions when there is in fact multiple control, some EOs would persist during the reinforcement intervals of the test conditions and may continue to evoke problem behavior. Hagopian, Rooker, Jessel, and DeLeon (2013) reported 53% of the FAs from 176 inpatient analyses to be undifferentiated before any modifications. This, paired with the relatively high outcomes of multiple control following all modifications (33.3%), suggests that synthesizing suspected contingencies into one condition may prevent initially undifferentiated outcomes. By contrast, synthesizing contingencies may increase the probability of false-positive outcomes in which some contingencies included in the test condition may not directly influence problem behavior. Continued research into procedures for evaluating the validity of the components of synthesized contingencies is warranted, as is research on the clinical implications of including too many or too few contingencies in analyses.

The fifth factor that may be responsible for the strong control exerted in the IISCAs was that the contingencies and materials included in the analyses were the same as those described by caregivers as evoking problem behavior and eliminating problem behavior after they had been delivered. The current study provides evidence of the interview's utility as a component of a functional assessment process. Nevertheless, eight of the 30 analyses required redesign before differentiated results were obtained. These results underscore the notion that the interview simply allowed the discovery of possible controlling variables, but that the analysis is necessary to demonstrate the validity of those potential discoveries (Hanley, 2012). Future research on how to conduct the open-ended interviews and how to make decisions regarding analysis design from interviews is warranted at this time.

By synthesizing all reported reinforcers into one test condition, the IISCA appears to have (a) reduced the number of sessions required to demonstrate the function of problem behavior, (b) allowed sufficient control by the contingency in a single consultation or outpatient visit, and possibly (c) increased the ecological validity of the assessment, because only those EOs and reinforcers that were reported to evoke or terminate behavior, respectively, were included in analyses. The shortest IISCA took as little as 15 min to conduct, representing a 96% decrease in the time required to conduct the shortest analysis in Iwata et al. (1982/1994). However, there is no obvious minimum duration required for an analysis. An assessment should last only as long as it takes to demonstrate a functional relation. Greater efficiency may be achieved by reconsidering the unit of analysis, which is typically a session-by-session comparison of mean rates. Perhaps within-session analysis of rate of behavior in a single test session while the reinforcer is present or absent may be sufficient.

STUDY 2: WITHIN-SESSION ANALYSIS OF INITIAL TEST SESSIONS

Roane, Lerman, Kelley, and Van Camp (1999) described the addition of secondary measures during analyses that allowed the isolation of problem behavior during the reinforcer-present intervals (RPI) and reinforcer-absent intervals (RAI) to help clarify the effects of contingencies on problem behavior when an FA is undifferentiated. According to these authors, if a contingency exists between problem behavior and a reinforcer, problem behavior should be eliminated when the reinforcer is present because (a) there is no environmental change following problem behavior during that interval, and (b) the presence of the reinforcer abolishes its value. By contrast, the probability of problem behavior should be high in the absence of the reinforcer because (a) there is an immediate and consistent environmental change following problem behavior during that interval, and (b) the absence of the reinforcer establishes its value and therefore increases the probability that a problem behavior will occur.

Roane et al. (1999) suggested that this within-session analysis might help to elucidate the controlling contingency. For two of their three participants who showed a socially mediated function, responding occurred almost exclusively during the RAI in the first test session. Thus, Study 2 was conducted to determine if within-session analysis of a single test session may be useful as the primary means to detect the function of problem behavior for our participants.

Method

Participants and settings. Of the 30 analyses from Study 1 in which all videotaped data were available and for which the reinforcers were of consistent and extended duration, 10 were included for further within-session analyses. For example, Kat's (Context 1) and Will's analyses were excluded because the reinforcement intervals for attention and edible items, respectively, were short and variable.

Interobserver agreement. Interobserver agreement on reinforcement duration was included because the duration of the RPI and RAI was required to calculate individual rates of responding during each session. This agreement was calculated as a duration-based, partial-agreement measure. The duration of each reinforcer delivery recorded by the secondary observer within each 10 s interval was compared to the duration recorded by the primary observer. The smaller duration was divided by the larger duration and a mean percentage was calculated.

Interobserver agreement data were collected for at least 29% of sessions (range, 29% to 40%), and mean agreement across participants ranged from 84% to 100% (range of session scores was 72% to 100%).

Data analysis. A within-session analysis of problem behavior in the first test session of each FA was conducted. Rate of problem behavior during the RAI was calculated by dividing the total number of responses that occurred during an interval in which the reinforcer was absent by the duration of that interval. The individual RAIs could vary and depended on when the participant exhibited problem behavior, because the RAI terminates after a single instance of problem behavior. The rate of problem behavior during the RPI was calculated by dividing the total number of responses that occurred during an interval in which the reinforcer was present by the total number of seconds of that interval. The RPI was not dependent on problem behavior and was typically 30 s per interval.

Within-session response patterns were also represented in a cumulative record for every test session conducted for selected analyses. A cumulative representation of the problem behavior across sessions provided a depiction of the learning that may occur during an FA as well as the extent to which the putative contingency was controlling behavior. Sessions were divided into 1-s bins, and the intervals in which the reinforcers were absent and present were distinguished. Thus, it was possible to determine the pace of responding during each test session as well as the precise interval in which problem behavior occurred. Furthermore, optimal responding would yield a steady slope with response–pause patterns and short RAIs.

Results and Discussion

The results of the within-session analysis of the first test session from the IISCAs for all 10 participants are presented in Figure 2. Overall, higher rates of responding were observed during the RAIs (M = 0.3 responses per second) in comparison to the RPIs (M = 0.01 responses per second). Control by the reinforcement contingency was evident in eight of 10 analyses. In addition, problem behavior was exclusively observed during the RAIs in four of those eight analyses.

Patterns of problem behavior within the first 3- to 5-min test session of the analysis mirrored the differentiated results obtained across the five to seven sessions of the full IISCAs in eight

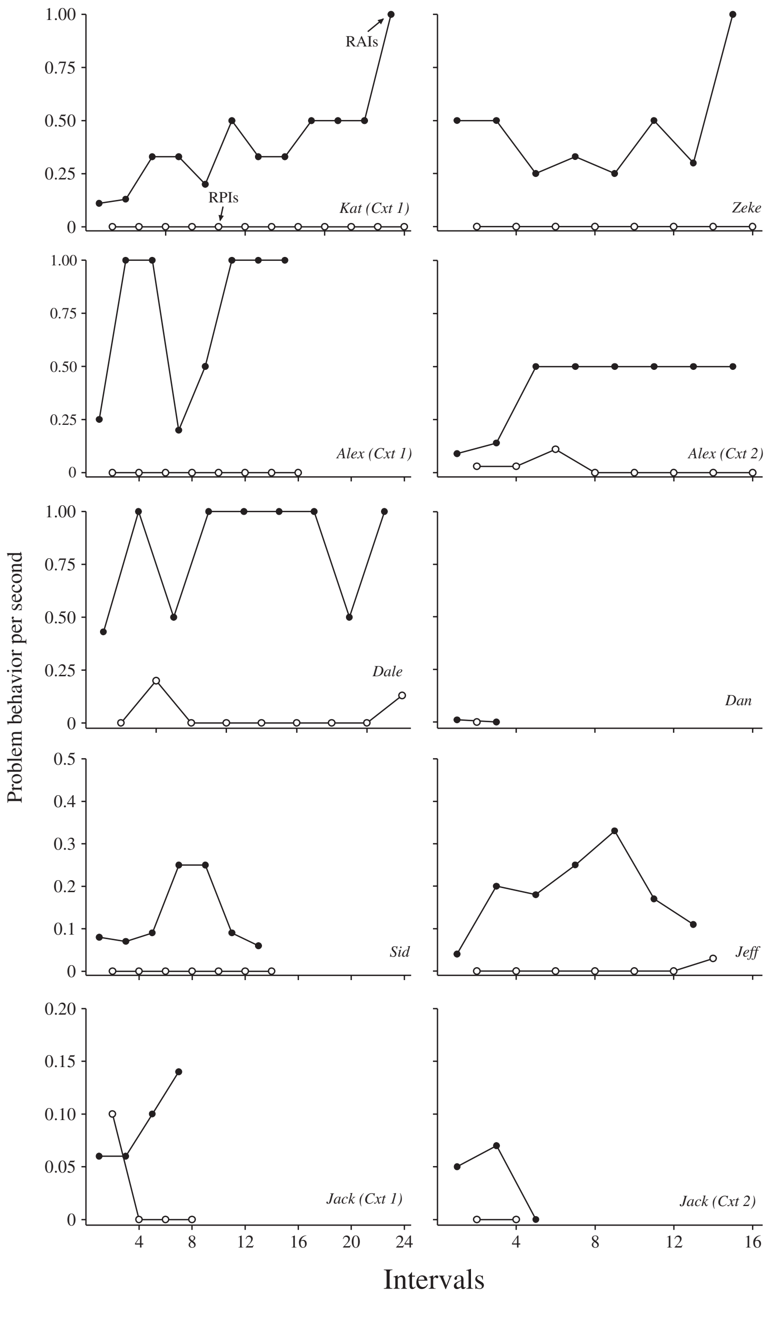

Figure 2. Analyses of the first session from the full IISCA for 10 participants. RAI = reinforcer-absent intervals; RPI = reinforcer-present intervals.

of 10 analyses. In addition, the differences observed across RAI and RPI were replicated three to 11 times, repeatedly demonstrating a strong functional relation within 3 to 5 min.

Figure 3 depicts cumulative responding across all test sessions for two participants. Data for Alex and Dan were graphically depicted to show the development of control by the

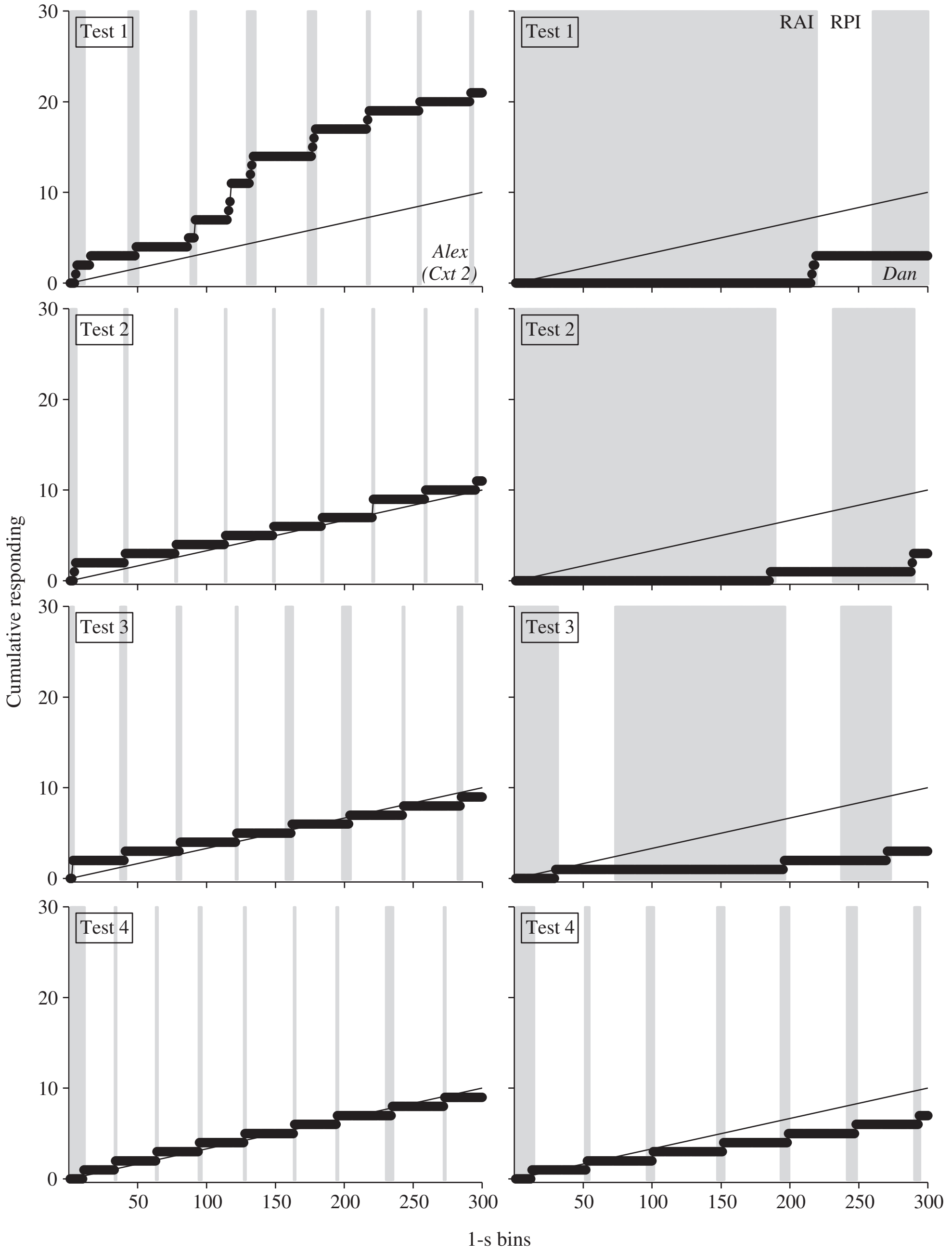

Figure 3. Cumulative records of responding for Alex (Context 2; left) and Dan (right) during test conditions of the IISCAs. RAI = reinforcer-absent intervals; RPI = reinforcer-present intervals. The solid line represents the optimal slope of responding.

contingency that sometimes occurs during an IISCA. Longer durations of RAIs with bursts of problem behavior both in and outside the RAIs were initially observed for Alex during the first test session. By the second test session, a distinct response–pause pattern was observed with overall shorter durations of RAIs. Although Alex maximized reinforcement deliveries in the first session, his problem behavior became more optimal across sessions as the number of problem behaviors per reinforcer delivery decreased. Strong control by the contingency was evident in subsequent sessions. His within-session analysis showed initially excessive problem behavior coming under control of the programmed contingency in the IISCA.

By contrast, Dan contacted the programmed reinforcement only once during the first test session. With each successive session, problem behavior began to occur sooner during the RAI, increasing the total number of reinforcer deliveries. By the fourth test session, problem behavior had come under control of the programmed contingency.

The levels of problem behavior changed in different directions for Alex and Dan; however, they eventually converged along a similar pace and distribution. Both types of learning evident in their data are beneficial during FAs of problem behavior. For Alex, reducing response rates minimizes risk by reducing the overall amount of problem behavior. For Dan, the eventual increase in response rate allowed behavioral function to be determined and treatment to be initiated.

Learning during an FA has often been framed as a limitation of the procedures suggestive of artifactual control of problem behavior (i.e., problem behavior is controlled by a contingency in the analysis that does not influence problem behavior outside the analysis; see Cooper, Heron, & Heward, 2007, p. 506). Our results suggest that learning in analyses may be better construed as problem behavior coming under more precise and predictable control of a reinforcement contingency. The quick and strong control by the contingency also seemed to weaken any artifactual control argument.

Roane et al. (1999) included session-by-session depictions of the rate of responding in the presence and absence of reinforcement to clarify behavioral function. Similarly, Vollmer, Iwata, Zarcone, Smith, and Mazaleski (1993) included within-session depictions of problem behavior to elucidate functional relations when overall rates of problem behavior were undifferentiated across FA conditions. The current study differed from previous research in that we suggest that an analysis of a single test session may take the place of analyses with repeated sessions in some cases. This analysis, termed the single-test IISCA, would allow practitioners to complete an analysis in 3 to 5 min. In other words, the first session of an interview-informed test session sometimes appeared to be capable of serving as an FA. The RAIs were analogous to the test sessions, and the RPIs were analogous to the control sessions of a multielement analysis. Of interest is that the number of replications is often higher with the single-test IISCA than with that of a multielement analysis and is partly dependent on factors that are under the implementers' control, such as (a) the duration of the session, (b) the duration of the reinforcer interval, and (c) the frequency with which the evoking stimuli are presented.

Given the 80% success rate, the single-test IISCA may be useful in many, but not all, cases. For some participants, a 5-min exposure to the arranged contingencies may not be sufficient to evoke problem behavior reliably. For individuals like Dan, multiple sessions may be required before control by the contingency is evident. Although control may be achieved with a single test session, whether or not one test session would serve as a useful baseline for a treatment evaluation needs to be further assessed. Future research should be conducted to determine the extent to which single-test IISCAs correspond with full IISCAs and whether treatments develop properly after the single-test analyses. Others have considered extending analyses when initial results were undifferentiated (e.g., Kahng, Abt, & Schonbachler, 2001; Tarbox, Wallace, Tarbox, Landaburu, & Williams, 2004). The current results suggest that attention should also be directed to reducing analyses when initial results are clearly supportive of a functional relation.

GENERAL DISCUSSION

The influence that the analysis described by Iwata et al. (1982/1994) has had on the treatment of problem behavior should be celebrated, as it was in the 2013 special issue of the *Journal of Applied Behavior Analysis*. This FA methodology allowed a scientific demonstration of control over problem behavior by reinforcement contingencies and has led to efficacious treatments for multiple topographies of severe problem behavior (e.g., Campbell, 2003; Heyvaert, Maes, Van den Noortgate, Kuppens, & Onghena, 2012; Kahng, Iwata, & Lewin, 2002). Before the advent of the Iwata et al. format, practitioners were more reliant on powerful, arbitrarily selected punishers to suppress problem behavior to manageable levels (Axelrod, 1987).

There are, however, many convincing ways to demonstrate causal relations and, similar to any other experimental procedures, there need not be any immutable ones (Baer et al., 1968; Sidman, 1960). FA methods of greater efficiency,such as the brief analysis, trial-based analysis, and latency-based analysis, have evolved. Rather than shorten the number or duration of sessions, this study showed how modifications to the core procedural components of Iwata et al. (1982/1994) yield efficient analyses that are capable of exerting strong control over problem behavior. With 30 replications, Study 1 demonstrated that the IISCA was an effective and efficient tool for identifying socially mediated variables that contribute to problem behavior across subjects, contexts, and contingencies. Like any functional analysis, the IISCA is not equipped to demonstrate control by automatic reinforcement contingencies. When an interview suggests control by automatic reinforcement, arrangement of a series of alone sessions is recommended (Querim et al., 2013); treatment is then implemented if problem behavior persists despite the absence of socially mediated contingencies (see, e.g., Potter, Hanley, Augustine, Clay, & Phelps, 2013). However, automatic reinforcement was never suspected for participants in the current study because all interviews suggested socially mediated contingencies.

The utility of the IISCA was evaluated across children and adults, with and without diagnoses, with and without age-appropriate language abilities, mild to severe forms of problem behavior, and in settings from public school classrooms to outpatient clinics. The breadth of variation among the analyses demonstrated the generality of the IISCA across demographics and contexts relevant to applied behavior analysts. Nevertheless, continued application of IISCAs with different topographies of problem behavior and in different contexts, especially those contexts in which the most severe forms of problem behavior are addressed (e.g., inpatient hospitals), is needed to understand the generality of this method.

A limitation of the IISCA format may be the inability to determine control of individual contingencies when more than one is synthesized in the analysis (Fisher, Greer, Romani, Zangrillo, & Owen, 2016). Knowledge of the influence of isolated contingencies may satisfy an analytical curiosity but may be of little practical value if problem behavior can be sufficiently treated in the context in which it occurs by synthesizing the contingencies, as was evident in Hanley et al. (2014) and more recently in Santiago, Hanley, Moore, and Jin (2016).

Future research should be directed towards understanding the relative advantages and disadvantages of isolating or synthesizing contingencies that are suspected of influencing problem behavior in FAs as well as in treatment analyses. Furthermore, as more analyses that involve synthesized contingencies are published, it will become more apparent that certain contingencies may serve as reinforcement only when combined because they require the interaction to affect problem behavior (e.g., Bowman et al., 1997; Ghaemmaghami, Hanley, Jin, & Vanselow, in press; Hagopian et al., 2007; Hanley et al.; Santiago et al.). Therefore, attempts to confirm the relevance of components of synthesized contingencies will require going beyond conducting an analysis of isolated contingencies.

Study 2 examined response patterns within the initial test session for 10 of the 30 IISCAs. These within-session analyses yielded differentiated responding in 80% of analyses in one fifth the time of the full IISCA while usually providing three times the number of replications as provided via session-by-session analysis. We suggest that time need not be considered an obstacle to a scientific determination of the function of problem behavior before its treatment (cf. Applegate, Matson, & Cherry, 1999).

Considering the collective results, it has become increasingly difficult to support the criticism that an FA places the client in dangerous contexts that involve prolonged exposure to environmental events that pose the risk of unacceptable rates of problem behavior relative to those already experienced in day-to-day life (see Cooper et al., 2007, p. 506, for a list of these limitations). Because problem behavior was rarely observed during the control condition or during the reinforcement interval, the probability of problem behavior occurring during an IISCA was isolated to moments that lasted only a few seconds. Second, one of the core components of the IISCA was to reinforce milder forms or precursors to the more severe problem behavior in the class of behavior that produced reinforcement. The likelihood of the client engaging in dangerous behavior that threatened his or her safety or the safety of the implementer decreased when both precursors and severe problem behavior were immediately reinforced on a continuous reinforcement schedule (Borrero & Borrero, 2008; Smith & Churchill, 2002). The result of the full or single-test IISCA yielded a very brief exposure to limited presentations of EOs that usually evoked mild forms of problem behavior at predictable and momentary intervals with participants who all presented with dangerous levels, forms, and intensities of problem behavior in their everyday interactions outside the analyses.

Consideration of response rate in and outside the reinforcement interval in test sessions may also be helpful for predicting the effects of function-based treatments in addition to promoting efficient analyses. For example, a function-based treatment that consists of differential reinforcement (e.g., functional communication training; Carr & Durand, 1985; Tiger, Hanley, & Bruzek, 2008) will not necessarily eliminate problem behavior if problem behavior continues unabated during the RPI. Punishment (Hagopian et al., 1998) or other arbitrary reinforcement procedures (Fisher, Piazza, Bowman, Hagopian, & Langdon, 1994) will likely be necessary when problem behavior persists across reinforcement intervals or during control sessions. The humane goals made possible with function-based treatments will most likely be realized when functional assessment processes continue until reinforcement intervals occur without problem behavior. If that is not the case, additional interviews and observations should be used to design an analysis that involves a better synthesized contingency.

Although the overwhelming number of published FAs have resulted in differentiated analyses (Beavers et al., 2013; Hanley et al., 2003), the degree of differentiation or amount of control yielded via different FA formats remains an empirical question. Future research should compare not only the efficiency of the different FA formats but also the level of control over problem behavior that is achieved with each type. It will be important to determine if strong control over problem behavior can be obtained quickly and safely in a specific format and if the extent of control demonstrated in FAs is indeed related to treatment outcomes.

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SUPPORTING INFORMATION

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