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COMPARISONS OF SYNTHESIZED AND INDIVIDUAL REINFORCEMENT CONTINGENCIES DURING FUNCTIONAL ANALYSIS

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Abstract

Researchers typically modify individual functional analysis (FA) conditions after results are inconclusive (Hanley, Iwata, & McCord, 2003). Hanley, Jin, Vanselow, and Hanratty (2014) introduced a marked departure from this practice, using an interview-informed synthesized contingency analysis (IISCA). In the test condition, they delivered multiple contingencies simultaneously (e.g., attention and escape) after each occurrence of problem behavior; in the control condition, they delivered those same reinforcers noncontingently and continuously. In the current investigation, we compared the results of IISCA with a more traditional FA in which we evaluated each putative reinforcer individually. Four of 5 participants displayed destructive behavior that was sensitive to the individual contingencies evaluated in the traditional FA. By contrast, none of the participants showed a response pattern consistent with the assumption of the IISCA. We discuss the implications of these findings on the development of accurate and efficient functional analyses.

Keywords

assessment of problem behavior; false-positive outcome; functional analysis; independent effects; interaction effects

The development of functional analysis (FA) represents one of the most important advancements in the treatment of severe problem behavior (Beavers, Iwata, & Lerman, 2013), an event in the history of behavior analysis that has been described as landmark (Betz & Fisher, 2011). Identification of the antecedents that evoke and the consequences that reinforce problem behavior via an FA enables effective behavioral intervention. It does so because an FA provides information on (a) how to discontinue the contingency between problem behavior and its reinforcer (i.e., extinction) and (b) how to deliver that reinforcer contingent on an appropriate response or on a time-based schedule (Fisher & Bousse, 2011; Vollmer & Athens, 2011; Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993).

The FA method developed by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) has been the most widely used, researched, and cited form of functional analysis (Beavers et al., 2013; Hanley, Iwata, & McCord, 2003). This method involves a control condition and a series of test conditions based on the hypothesized operant functions of self-injurious behavior (SIB) described by Carr (1977): (a) social-positive reinforcement (e.g., attention), (b) social-negative reinforcement (e.g., escape from nonpreferred activities), or (c) automatic reinforcement (e.g., sensory stimulation).

Each FA test condition in the Iwata et al. (1982/1994) method has three functional components: a unique discriminative stimulus (S^D), a specific establishing operation (EO), and a putative reinforcing consequence (Betz & Fisher, 2011). Iwata et al. included a unique S^D in each test condition to decrease the likelihood that the reinforcement effects from one test condition carried over and affected levels of the target response in other test conditions (i.e., multiple-treatment interference). They included the EO for the putative reinforcer in each test condition to evoke the target response and to increase the likelihood that it contacted the reinforcing consequence. Finally, the Iwata et al. method included a specific reinforcing consequence, typically delivered on a dense (fixed-ratio 1) schedule.

Hanley et al. (2003) and Beavers et al. (2013) described several procedural variations of the Iwata et al. (1982/1994) FA method. In some cases, researchers have altered this method based on indirect assessments, direct assessments, or both (Betz & Fisher, 2011; Hanley et al., 2003). Indirect assessments are ones in which there is no direct observation of the target behavior; instead, informants who have observed the individual's target behavior answer questions about behavioral function via interviews or rating scales (e.g., Hanley, 2012; Roscoe, Schlichenmeyer, & Dube, 2015). Indirect assessments, when used alone, tend to have poor reliability and validity for identifying the functions of problem behavior (Kelley, LaRue, Roane, & Gadaire, 2011; Rooker, DeLeon, Borrero, Frank-Crawford, & Roscoe, 2015). By contrast, a direct assessment involves observation and measurement of the target behavior and the antecedents and consequences that precede and follow it in the natural environment (Bijou, Peterson, & Ault, 1968; Roscoe et al., 2015; Thompson & Iwata, 2001, 2007). Direct assessments tend to be highly reliable, and they often find significant correlations between problem behavior and certain putative reinforcers (e.g., attention, escape; Thompson & Iwata, 2001). However, direct assessments typically produce unacceptably high levels of false-positive outcomes (e.g., they inaccurately identify attention as a reinforcer for problem behavior when attention is only temporally associated with the response; Thompson & Iwata, 2001, 2007). Nevertheless, indirect and direct assessments have been successfully used to modify FA test and control conditions after an initial FA produced inconclusive results (e.g., Bowman, Fisher, Thompson, & Piazza, 1997; Fisher, Adelinis, Thompson, Worsdell, & Zarcone, 1998; Roscoe et al., 2015; Tiger, Hanley, & Bessette, 2006).

Hanley, Jin, Vanselow, and Hanratty (2014) described a marked departure from prior FA methods in which they used a structured but open-ended interview (see the appendix of Hanley, 2012) in combination with brief, informal observations to develop an efficient FA that included a single test condition and a single control condition, henceforth referred to as an interview-informed synthesized contingency analysis (IISCA). The IISCA differs from a

traditional FA (i.e., one based on Iwata et al., 1982/1994) in at least two important ways. First, a traditional FA exposes the individual to a control condition and one or more test conditions in which the effects of individual reinforcement contingencies are evaluated one at a time to identify the specific contingency or contingencies that maintain problem behavior. By contrast, the IISCA combines multiple EOs, S^Ds, and consequences from multiple contingencies into a single test condition, but does not isolate any specific operant function. Second, Iwata et al. (1982/1994) derived the original test conditions of a traditional FA from empirical research that showed that individual reinforcement contingencies often maintained problem behavior (e.g., Berkson & Mason, 1963; Carr, Newsom, & Binkoff, 1976; Lovaas, Freitag, Gold, & Kassorla, 1965). Therefore, a traditional FA generally starts with the evaluation of individual but general contingencies (positive, negative, and automatic reinforcement) and proceeds to the assessment of more idiosyncratic (or combined) contingencies only when the individual's problem behavior proves to be insensitive to those general contingencies.

By contrast, the IISCA uses the results of a structured interview and informal observations to generate a single test condition that typically includes multiple contingencies that may be general (e.g., escape) or idiosyncratic (e.g., reinforcement of the individual's mands contingent on problem behavior). Thus, the traditional FA assumes that individual contingencies produce primarily independent effects on problem behavior, and Iwata et al. (1982/1994) designed the traditional FA to test for those independent effects. By contrast, the IISCA assumes simultaneous (or interactive) control of behavior by multiple contingencies (Sidman, 1960/1988); however, Jessel, Hanley, and Ghaemmaghami (in press) did not design the IISCA to test for those interactive effects (except with one participant, described below).

An *interactive effect* is one in which two or more independent variables act simultaneously to produce different effects on responding than the effects produced by those variables individually. The primary method used for analyzing interactive effects is for the experimenter to compare a test condition that combines (or synthesizes) the relevant independent variables with a set of control conditions that present each of the relevant independent variables in isolation (Barlow & Hersen, 1984; Sidman, 1960/1988). Thus, a direct within-subject comparison of the IISCA and traditional FA procedures provides a way to compare the interaction-effects assumption of the IISCA with the independent-effects assumption of the traditional FA. Figure 1 shows four relevant outcomes that might result from such a comparison.

Figure 1 (top) shows hypothetical data that are consistent with the assumption of the traditional FA regarding independent contingency effects. The results of the traditional FA show that the EO and contingency for tangible positive reinforcement evoked and maintained problem behavior, whereas the results of the IISCA show no additional effect (i.e., no interaction effect) of synthesizing tangible positive reinforcement with an escape contingency and contingent attention. Figure 1 (second panel) shows hypothetical data that are consistent with the assumption of the IISCA that problem behavior is primarily sensitive to simultaneous (or interactive) control of problem behavior. The results of the traditional FA show no evidence of independent effects for any of the individual contingencies (and their

respective EOs), whereas the results of the IISCA show that the EOs and contingencies associated with escape and attention interacted to maintain problem behavior. Figure 1 (third panel) depicts hypothetical data in which the results of the traditional FA show that the contingencies (and corresponding EOs) for tangible-positive reinforcement and for escape-maintained problem behavior when implemented individually, albeit at moderate rates. The results of the IISCA show that the EOs and contingencies associated with escape and those associated with tangible items interacted to produce higher and more consistent rates of problem behavior than either contingency (and its respective EO) produced individually. That is, the synthesized test condition of the IISCA produced more robust effects than any of the individual contingencies of the traditional FA. Overall, the hypothetical data in Figure 1 (third panel) illustrate a situation in which an individual's problem behavior is sensitive to both individual and synthesized contingencies (i.e., both independent and interactive effects). Finally, Figure 1 (fourth panel) depicts hypothetical data in which an individual's problem behavior is insensitive to both individual and synthesized contingencies.

A large body of research has shown that problem behavior is often sensitive to the individual contingencies that are implemented in traditional FAs (see Beavers et al., 2013). In addition, a growing body of research by Hanley and colleagues has shown that problem behavior is often sensitive to one or more of the contingencies implemented simultaneously in an IISCA (Ghaemmaghami, Hanley, & Jessel, in press; Hanley et al., 2014; Jessel et al., in press). However, investigators have conducted within-subject comparisons of individual and synthesized contingencies with just one participant (Gail in Hanley et al., 2014, who showed a response pattern similar to the hypothetical results shown in the second panel of Figure 1). Thus, this is the only published case for which it is possible to compare the independent and interactive effects of FA contingencies. Therefore, in this study we conducted traditional FAs (that analyzed individual contingencies) and IISCAs (that analyzed synthesized contingencies) with five consecutive participants to provide information on the extent to which these participants showed problem behavior that was (a) sensitive primarily to individual contingencies, (b) sensitive primarily to the interactive effects of synthesized contingencies, or (c) sensitive to both individual and interactive contingency effects.

METHOD

Subjects

Five children who had been referred to a severe behavior disorders program at a university-based clinic for the assessment and treatment of severe problem behaviors participated. Participants attended the clinic 2 to 5 days per week for 3 to 6 hr per day.

Alan, a 3-year-old boy who had been diagnosed with autism spectrum disorder (ASD), engaged in aggression (hitting, pushing, kicking) and SIB (head hitting). He communicated using gestures and picture exchanges. Allie, a 5-year-old girl who had been diagnosed with ASD, engaged in SIB (body slamming to the ground). She communicated using gestures and card touches. Cameron, a 7-year-old boy who had been diagnosed with ASD, engaged in SIB (head banging) and aggression (scratching, biting). He communicated using gestures and picture exchanges. Sylvia, a 5-year-old girl who had been diagnosed with oppositional defiant disorder, displayed aggression (hitting, kicking, biting) and property destruction

(e.g., throwing materials). She spoke in complete and complex sentences. Tina, an 8-year-old girl who had been diagnosed with oppositional defiant disorder, attention deficit hyperactivity disorder, combined type, and bipolar disorder, engaged in aggression (hitting, kicking, biting), SIB (hair pulling), and property destruction (throwing task materials). She spoke in complete and complex sentences.

Setting and Materials

We conducted the IISCAs and traditional FAs in clinic therapy rooms (3 m by 3 m) equipped with one-way observation panels. We used padded treatment rooms for Alan's, Allie's, and Cameron's sessions due to the health risks associated with their SIB. We followed the safety precautions described by Betz and Fisher (2011) to minimize any health risks associated with the FAs.

Each therapy room contained a table, chairs, and work or leisure items relevant to the condition. For the traditional FA, we included leisure items in certain sessions (as specified below) that we identified based on caregiver nomination and a paired-stimulus preference assessment (Fisher, Piazza, Bowman, & Amari, 1996; Fisher et al., 1992). We included demand materials that we identified based on caregiver nomination for Allie, Cameron, and Sylvia. For Alan and Tina, we used caregiver and teacher nomination to identify a set of instructions that we systematically assessed via a demand-latency assessment (Call, Pabico, & Lomas, 2009) and choice arrangement similar to a paired-choice stimulus assessment. For example, each task was presented in a choice arrangement with every other task (e.g., a choice between cleaning and math problems; Fisher et al., 1992); selection resulted in the use of graduated guidance to complete the task, which resulted in a hierarchy of task preferences. We included tasks in the relevant tests conditions (listed below) that produced the shortest latencies to problem behavior and lowest preference rankings relative to other tasks. Similarly, we used the results of the open-ended interview and structured observation session (both described below) to construct the IISCA conditions, including the materials and demands (described below).

Measurement

Trained observers collected data on the frequency of target responses using laptop computers with a specialized data-collection program (DataPal). We used the computer program to convert data collected during the IISCA and traditional FA to a rate measure (responses per minute). We graphed the data from the structured observations as a cumulative record. For Alan, Cameron, Sylvia, and Tina, we defined *aggression* as forceful contact of the patient's feet, legs, arms, or hands with the therapist's body from a distance of at least 15 cm and contact between the participant's teeth and any portion of the therapist's body or clothing. For Sylvia and Tina, we defined *property destruction* as hitting or kicking hard surfaces (e.g., walls) from a distance of at least 15 cm with force, knocking over desks, or throwing task materials. For Tina, we defined *SIB* as holding her hair with her hand and forcefully pulling her hair away from her head. For Alan and Cameron, we defined *SIB* as hitting his head against a therapist's body (Alan) or the ground (Cameron) from a distance of at least 15 cm with force. For Allie, we defined *SIB* as contact between her back, stomach, or buttocks and the floor from a distance of at least 15 cm.

We assessed interobserver agreement by having a second observer simultaneously but independently record data during at least 19% of sessions for each participant. To calculate exact-agreement interobserver agreement, we partitioned sessions into successive 10-s intervals and compared observer records in each interval. If both observers recorded the same number of responses for a specific target behavior in an interval (including zero), we scored that interval as an agreement for that behavior. For each target behavior, we summed the number of agreements in a session and then divided that number by the total number of intervals in a session and converted the resulting quotient to a percentage. Coefficients during the structured observation averaged 97% (range, 90% to 100%) for Alan, 93% (range, 84% to 100%) for Allie, 93% (range, 71% to 100%) for Cameron, 96% (range, 89% to 100%) for Sylvia, and 91% (range, 74% to 100%) for Tina. Coefficients during the IISCA and traditional FA averaged 98% (range, 87% to 100%) for Alan, 99% (range, 70% to 100%) for Allie, 99% (range, 83% to 100%) for Cameron, 99% (range, 97% to 100%) for Sylvia, and 97% (range, 95% to 100%) for Tina.

Design

We used a multielement design to identify the function of problem behavior during both the IISCAs and traditional FAs. We used an ABAB reversal design for Alan, Allie, and Cameron and an AB design for Sylvia and Tina to compare the results obtained with the IISCAs and traditional FAs. We randomized and counterbalanced the ordering of the IISCAs and traditional FAs across participants. Finally, we conducted the open-ended interview and then the structured observation session shortly before the IISCA and used the information from those preassessments to design the IISCA using procedures based on Hanley et al. (2014). We did not use the results of these preassessments to modify the traditional FAs; instead, we used our typical intake procedures that included a comprehensive evaluation prior to placement (record review, behavioral history, and behavioral observation) and structured preference assessments to select the materials used in the control, attention, and tangible conditions. In addition, we informally interviewed caregivers to select the materials used and demands issued for the traditional FA. We used similar, but not identical, materials during the IISCA and traditional FA. Table 1 depicts the relevant stimuli included in each condition of the IISCA and traditional FA. Trained behavior therapists (ranging from bachelor to postdoctoral level) collected all preassessment information and implemented the IISCA and traditional FA, with the exception of Sylvia whose caregiver conducted portions of the assessment under the close supervision of the first two authors and the corresponding author.

Open-Ended Functional Assessment Interview

One therapist conducted the open-ended functional assessment interview with the patient's caregiver using the procedures described by Hanley et al. (2014). The interview lasted approximately 25 min. Each caregiver responded to 20 questions. Questions targeted seven broad areas, including identification of the operational definitions for the target problem behavior, identification of the antecedent conditions likely to evoke problem behavior, and determination of the consequences that typically followed problem behavior in the natural environment. The therapist often asked follow-up questions to clarify or gain more information about caregiver responses to particular items.

Structured Observations

After the open-ended functional assessment interview, the therapist conducted a structured observation in one continuous session that lasted about 25 min, using procedures outlined in Hanley et al. (2014). To evaluate the effects of various EOs for problem behavior related to positive reinforcers, the therapist began the session by providing free access to preferred toys and attention and delivering no demands for 4 min; this served as the control condition for the structured observation. Then, at approximately the 4-min mark, the therapist introduced an EO for problem behavior by restricting access to the positive reinforcer with which the participant currently interacted. For example, Cameron engaged in isolated play with an iPad at the 4-min mark, and the therapist removed the iPad but continued to talk to Cameron without issuing any demands (i.e., the therapist introduced only the EO for tangible reinforcement because that is what the participant consumed at the time mark). If the participant engaged with multiple positive reinforcers at the prescribed time mark (i.e., playing with toys and the therapist simultaneously), the therapist removed both positive reinforcers as the EO. The therapist delivered the restricted reinforcer (e.g., the iPad) for about 20 s either contingent on problem behavior or after 30 s, whichever came first. This process of introducing the EO for a reinforcer after the participant interacted with that reinforcer and then returning it either contingent on problem behavior or after 30 s elapsed continued for about 4 min.

At approximately 8 min into the structured observation session, the therapist again provided free access to preferred toys and attention for another 4 min. At approximately 12 min into the session, the therapist restricted the participant's access to toys, attention, or both (as described above) and simultaneously issued a series of nonpreferred demands reported to evoke problem behavior during the open-ended interview (i.e., a combined EO that included both positive and negative reinforcement). For example, for Cameron, the therapist removed the iPad and issued demands that reportedly evoked problem behavior. The therapist discontinued demands and returned the positive reinforcer (e.g., attention, toys, or both) for about 20 s contingent on problem behavior or after 30 s elapsed, whichever came first. At the end of the reinforcement interval, the therapist again removed the positive reinforcer the participant engaged with and simultaneously introduced nonpreferred demands. This process of the therapist simultaneously introducing the EOs for escape and the positive reinforcer and then terminating the demands and returning the positive reinforcer either contingent on problem behavior or after 30 s elapsed continued for about 4 min.

At about 16 min into the session, the therapist again provided free access to preferred toys and attention for another 4 min. At about 20 min into the session, the therapist and participant briefly left the treatment room and took a short walk while the observers removed the toys from the room. When the therapist and participant returned, the therapist issued a series of nonpreferred demands reported to evoke problem behavior during the open-ended interview (i.e., the therapist presented only the EO for negative reinforcement). The therapist discontinued demands for about 20 s contingent on problem behavior or after 30 s elapsed, whichever came first. At the end of the reinforcement (i.e., escape) interval, the therapist again introduced nonpreferred demands. This process of the therapist introducing the EO for escape and then terminating the demands contingent on problem behavior or after

30 s elapsed continued for about 4 min. For participants who displayed problem behavior during the structured observation (Alan, Allie, and Cameron), we examined the cumulative record of responding to identify the individual EO or combined EOs that evoked problem behavior.

Synthesized Analysis

Synthesized (test)—We used the results of the open-ended interview and structured observations to design the synthesized test condition for each participant using procedures outlined by Hanley et al. (2014). That is, to construct the test condition, we combined each of the EOs identified during the interview or the structured observations into a single synthesized EO. Contingent on problem behavior, we removed those EOs by delivering the corresponding reinforcers for 20 s. For example, for Cameron, we withdrew the iPad and initiated nonpreferred demands as the EO at the start of the test session, and we terminated those demands and returned the iPad for 20 s contingent on problem behavior. Based on the interview and structured observations, we combined attention, tangible items, and demands into a synthesized contingency for the test condition for the other four participants. That is, we restricted attention and tangible items and initiated nonpreferred demands at the start of the test session, and we terminated the demands and provided access to attention and the tangible items contingent on problem behavior. Each test and control session lasted 5 min.

Toy play (control)—We used the results of the open-ended interview and structured observations to design the control condition for each participant using procedures outlined by Hanley et al. (2014). That is, the therapist delivered all of the putative reinforcers for problem behavior identified during the interview or structured observation throughout each control condition. For all participants, the therapist provided free access to tangible items, presented no demands, and delivered attention (e.g., “Nice job playing!”) approximately every 20 s throughout each control session. We added attention to the control condition for Cameron to approximate the rate of attention delivered when the therapist provided instructions during the synthesized test condition, despite the results of his interview and structured observation, which both suggested that attention was an unlikely reinforcer for his problem behavior.

Traditional FA

We conducted a traditional FA based on procedures described by Iwata et al. (1982/1994) with modifications outlined by Fisher, Piazza, and Chiang (1996) and Querim et al. (2013). That is, we conducted a series of consecutive ignore sessions to determine whether problem behavior persisted in the absence of social contingencies as a test for automatic reinforcement (Querim et al.). For all participants, we observed near-zero rates of problem behavior in this ignore condition. Therefore, we omitted these data from the figures (to simplify interpretation). In addition, we equated the durations of the EOs and reinforcement intervals across the social-reinforcement test conditions (Fisher, Piazza, & Chiang). We provide detailed descriptions of each FA condition below.

Toy play—The therapist provided access to highly preferred items and continuous access to attention in the form of spoken and physical attention. Preferred items remained freely available, and no demands were issued.

Attention—The therapist provided approximately 2 min of presession access to attention and a low-preference item. The therapist diverted attention towards activities such as completing paperwork or reading a magazine. Contingent on problem behavior, the therapist provided access to attention in the form of verbal reprimands for 20 s.

Tangible—The therapist provided approximately 2 min of presession access to the highly preferred items, after which the therapist began restricting access to the items. Contingent on problem behavior, the therapist provided access to the tangible item for 20 s.

Escape—The therapist instructed the participant to complete nonpreferred demands using a three-step, progressive prompting procedure (verbal, model, and physical guidance). The therapist delivered praise contingent on compliance with the verbal or modeled prompt. Contingent on problem behavior, the therapist provided a break (or escape) from the nonpreferred demands for 20 s.

RESULTS

Open-Ended Interview and Structured Observation

Alan's caregivers reported during the interview that he frequently displayed problem behavior when they restricted his access to tangible items (particularly an iPad) or when they instructed him to complete nonpreferred demands. In addition, the caregivers reported that they frequently delivered attention following problem behavior (e.g., talked to him in a soothing voice, held and rocked him, or some combination). Results of the structured observation session indicated that when Alan had free access to attention and tangible items, he consumed both reinforcers together during each opportunity. In addition, when the therapist restricted access to both attention and tangible items simultaneously, Alan displayed problem behavior during 75% of the occasions. Also, when the therapist delivered instructions in isolation, he displayed problem behavior during 80% of occasions. However, when the therapist combined all three EOs (i.e., restricted access to attention and tangible items and introduced nonpreferred demands), he displayed problem behavior on just one occasion (17%).

Allie's caregivers reported during the interview that she frequently displayed problem behavior when they restricted her access to tangible items or prompted her to make a change in her routine, which usually involved the introduction of nonpreferred demands. In addition, they reported that they provided attention following problem behavior. Results of the structured observation session indicated that when Allie had free access to attention and tangible items, she consumed both reinforcers each time (100%). In addition, when the therapist restricted access to both attention and tangible items simultaneously, Allie displayed problem behavior each time (100%). When the therapist delivered instructions in isolation, she displayed problem behavior during 33% of occasions, with problem behavior following each of the final four instructions. Finally, when the therapist combined all three

EOs (i.e., restricted access to attention and tangible items and introduced nonpreferred demands), she displayed problem behavior each time (100%).

Cameron's caregivers reported during the interview that he frequently displayed problem behavior when they restricted his access to tangible items (e.g., iPad, TV) and when they instructed him to complete nonpreferred tasks. Results of the structured observation session indicated that when Cameron had free access to attention and tangible items, he exclusively and continuously interacted with an iPad by himself. In addition, when the therapist restricted access to the iPad, Cameron immediately displayed problem behavior each time (100%). When the therapist combined the EOs for tangible reinforcement and escape by restricting access to the iPad and delivering nonpreferred demands, he displayed problem behavior on 75% of occasions. However, when the therapist introduced the EO for negative reinforcement in isolation by introducing nonpreferred demands after the observers removed the iPad from the room, he displayed no problem behavior (0%).

Sylvia's caregivers reported during the interview that she frequently displayed problem behavior when they restricted her access to attention (e.g., parent talking on the phone) or tangible items (e.g., Legos) and when they instructed her to complete nonpreferred tasks (e.g., to pick up toys). Results of the structured observation session indicated that when she had free access to attention and tangible items, she consistently consumed both. However, she did not display problem behavior during any of the EO manipulations during the structured observation.

Tina's caregivers reported during the interview that she frequently displayed problem behavior when they restricted her access to attention (e.g., parent busy cooking dinner) or tangible items (e.g., when her sister had one of Tina's preferred toys) and when they instructed her to complete nonpreferred tasks (e.g., to clean her room). Results of the structured observation session indicated that when Tina had free access to attention and tangible items, she consistently consumed both. However, like Sylvia, Tina did not display problem behavior during any of the EO manipulations during the structured observation.

IISCA and Traditional FA Results

Figure 2 shows the results of the IISCA and traditional FA for Alan, Allie, and Cameron. Initial results from the traditional FA for Alan (first phase, top) clearly showed that negative reinforcement (i.e., escape from nonpreferred demands) reinforced his problem behavior and that attention, when delivered contingent on problem behavior in isolation, did not. The initial results also suggested that tangible positive reinforcement may have reinforced Alan's problem behavior, but did so somewhat inconsistently (i.e., rates in four of six tangible sessions exceeded the zero rates of problem behavior observed in the control condition). Therefore, we conducted a pairwise analysis in the second phase that included only the tangible and toy play conditions, which produced equivocal results regarding a potential tangible function for problem behavior until we replaced the existing tangible items with an iPad in Session 31 based on parent report that removal of the iPad triggered problem behavior more consistently than other toys.

Results of the initial IISCA conducted with Alan (third phase, top) clearly showed that the synthesized contingency of escape combined with attention and tangible reinforcement produced higher rates of problem behavior than the control condition, which produced no problem behavior. During the fourth phase, we reintroduced the multielement traditional FA, which produced high and relatively stable rates of problem behavior in both the escape and tangible conditions and near-zero rates in the toy play and attention conditions. Finally, in the fifth phase, we reintroduced the IISCA and replicated the findings of the third phase. Overall, Alan displayed problem behavior reinforced by the individual contingencies of the traditional FA, with little to no evidence suggesting that the synthesized contingencies of the IISCA interacted to produce more robust reinforcement effects than the traditional FA.

Figure 2 (middle) shows the results of the IISCA and traditional FA for Allie. Results of the initial IISCA (first phase, middle) showed that the synthesized contingency of escape combined with attention and tangible reinforcers produced high and stable rates of problem behavior. Allie also displayed high rates of problem behavior in the first two toy play sessions of this phase, but then the rates of problem behavior decreased to zero for the remaining two toy play sessions. In the second phase, results of the traditional FA clearly demonstrated that tangible items reinforced problem behavior and that attention and escape, when implemented individually, did not. During the third phase, we reintroduced the IISCA, which produced high and relatively stable rates of problem behavior in the test condition and zero rates of problem behavior in the control condition. In the fourth phase, we reintroduced the traditional FA and replicated the findings of the second phase. Finally, Allie displayed low rates of problem behavior in half of the escape sessions. Therefore, to rule in or rule out an escape function more definitively, we compared her levels of responding in the escape condition with the toy play condition using the structured, visual inspection criteria described by Roane, Fisher, Kelley, Mevers, and Bouxsein (2013). These results failed to reach the criteria necessary for concluding that negative reinforcement contributed to the maintenance of problem behavior. Overall, Allie displayed problem behavior reinforced by the individual contingencies of the traditional FA, without any evidence suggesting that the synthesized contingencies of the IISCA interacted to produce more robust reinforcement effects than the individual contingencies of the traditional FA.

Figure 2 (bottom) shows the results of the traditional FA and IISCA for Cameron. As displayed in the first phase, during the traditional FA, tangible items reinforced problem behavior, but attention and escape did not. Results of the initial IISCA (second phase, bottom) showed that the synthesized contingency of escape combined with tangible reinforcement produced substantially higher rates of problem behavior than the control condition, but somewhat lower rates during the first two test condition sessions relative to the tangible condition of the traditional FA during the prior phase. We closely replicated the results produced by the traditional FA and IISCA in the third and fourth phases, respectively, and we observed approximately equal rates of problem behavior in the tangible condition of the FA and the test condition of the IISCA. Finally, Cameron displayed low to moderate rates of problem behavior in 30% of the escape sessions. Therefore, to rule in or rule out an escape function more definitively, we compared his levels of responding in the escape condition with the toy play condition using the structured visual inspection criteria described

by Roane et al. (2013). These results failed to reach the criteria necessary for concluding that negative reinforcement contributed to the maintenance of Cameron's problem behavior.

Overall, Cameron displayed problem behavior reinforced by the individual contingencies of the traditional FA, with little or no evidence suggesting that the synthesized contingencies of the IISCA interacted to produce an accentuated reinforcement effect relative to the traditional FA. In fact, when we observed differences (during the first two IISCA test sessions), it appeared that adding an escape contingency to the tangible contingency may have temporarily lessened the reinforcing effects of the tangible contingency, a potential interaction effect that would be in opposition to that predicted by the assumption of the IISCA.

Figure 3 (top) shows the results obtained during the IISCA and traditional FA conducted with Sylvia. Sylvia displayed no problem behavior during either the IISCA or the traditional FA, regardless of whether a therapist or her caregiver conducted the sessions.

Figure 3 (bottom) shows the results obtained during the IISCA and traditional FA conducted with Tina. During the first phase, a therapist conducted the IISCA, and Tina displayed no problem behavior. In the second phase, her caregiver implemented the IISCA, and Tina displayed high and stable rates of problem behavior in the synthesized test condition and near-zero rates of problem behavior in the control condition. During the third phase, a therapist conducted the traditional FA, which produced high and relatively stable rates of responding in the tangible condition and zero or near-zero rates of problem behavior in the other test and control conditions, indicating that tangible items reinforced problem behavior and that attention and escape did not. Overall, Tina displayed problem behavior reinforced by the individual contingencies of the traditional FA, without any evidence suggesting that the synthesized contingencies of the IISCA interacted to produce more robust reinforcement effects than the traditional FA.

Table 2 shows a summary of the individual and interactive functions of problem behavior identified during the open-ended interview, the structured observations, the S IISCA, and the traditional FA for all five participants. We used the results of the IISCA and traditional FA as the criterion variables to evaluate the validity of the open-ended interview and structured observations. Stimuli listed in regular typeface in Table 2 are ones that we confirmed to be functionally relevant because the traditional FA showed that the stimulus functioned as reinforcement for problem behavior. In addition, we also would have confirmed a stimulus as functionally relevant if the comparison of the results of the IISCA and traditional FA revealed an interaction effect involving that stimulus (e.g., response patterns similar to the hypothetical data presented in Panel 2 or Panel 3 of Figure 1). However, we did not observe such interactive effects with any of the five participants. Stimuli listed in boldface type in Table 2 are ones that we determined to be functionally irrelevant because they did not function as reinforcement for problem behavior either independently or interactively. Finally, the stimulus listed in italics is one that the structured observation failed to implicate that we later confirmed to be functionally relevant during the traditional FA. Across the five participants, the open-ended interview accurately implicated five functions (36%) and inaccurately implicated nine irrelevant functions (64%) compared to the results of the

traditional FA and IISCA. The structured observations accurately implicated three functions (43%), inaccurately implicated three irrelevant functions (43%), and failed to implicate one relevant function (i.e., the tangible function).

Thus, in summary, Alan's synthesized contingency included attention, tangible reinforcement, and escape, but only tangible items and escape reinforced his problem behavior; attention did not. Allie's synthesized contingency included attention, tangible reinforcement, and escape, but only tangible items reinforced her problem behavior; attention and escape did not. Cameron's synthesized contingency included tangible reinforcement and escape, but only tangible items reinforced his problem behavior; escape did not. Sylvia's synthesized contingency included attention, tangible reinforcement, and escape, but none of these consequences reinforced her problem behavior. It is important to note that both the IISCA and the traditional FA produced this same result with Sylvia (no problem behavior in any FA condition), as did the structured observation. Tina's synthesized contingency included attention, tangible reinforcement, and escape, but only tangible items reinforced her problem behavior; attention and escape did not. Finally, the four participants with differentiated traditional FA and IISCA results (Alan, Allie, Cameron, and Tina), all showed response patterns similar to the hypothetical data in Figure 1 (top), indicating that the functional contingencies that reinforced their problem behavior operated independently rather than interactively, which is consistent with the assumption of the traditional FA but not the IISCA.

Comparisons of the levels of experimental control—Jessel, Hanley, and Ghaemmaghami (2015) compared the results of 34 applications of the IISCA by their research group with all other types of FAs published in the extant literature using a rating scale that categorized analyses as showing strong, moderate, or weak experimental control. They concluded that the IISCA produced clearer outcomes and stronger experimental control than all other FA methods, including traditional, brief, trial-based, latency-based, and other FAs (Iwata et al., 1982/1994; Kodak, Fisher, Paden, & Dickes, 2013; Neidert, Iwata, Dempsey, & Thomason-Sassi, 2013; Northup et al., 1991). However, Jessel et al.'s results are limited in that they did not involve within-subject comparisons of the IISCA with the other FA methods. To address this limitation, we analyzed the strength of experimental control of the IISCA s and traditional FAs with the current within-subject data sets using the same scale as Jessel et al.

The first and second authors independently reviewed each of the relevant test–control comparisons for both the IISCA (synthesized vs. control) and the traditional FA (e.g., tangible vs. toy play) using the Jessel et al. (2015) scale, and we agreed on all ratings (exact agreement was 100%). We excluded Sylvia's data because she displayed no problem behavior during either analysis. Results indicated that the IISCAs and traditional FAs produced (a) strong experimental control for 75% and 80% of comparisons, respectively; (b) moderate experimental control for 0% and 20% of comparisons, respectively; and (c) weak experimental control for 25% and 0% of comparisons, respectively. Thus, our results showed that both methods typically produced strong experimental control. Our findings, derived from within-subject comparisons of the two approaches, do not support Jessel et al.'s assertion that the IISCA produces stronger experimental control than the traditional FA.

Function-based treatments—For Sylvia, who displayed no problem behavior during any observations or analyses, we provided training to her parents in general behavior-management strategies. We developed function-based treatments for the four participants who displayed problem behavior during the traditional FA and IISCA. Given that the results indicated that these four participants displayed problem behavior reinforced by individual contingencies, we developed functional communication training (FCT) interventions based on the individual contingencies implicated by the traditional FA. We compared the final three treatment data points from the treatment analyses with the baseline average for each participant and found that FCT reduced problem behavior by an average of 98% (Alan's tangible function = 100% reduction; Alan's escape function = 94% reduction; Allie's tangible function = 97% reduction; Cameron's tangible function = 100% reduction; Tina's tangible function = 100% reduction). These results provide further evidence that individual (rather than interactive) contingencies reinforced the problem behavior displayed by these four participants because function-based treatments designed to address individual contingencies proved to be highly effective.

DISCUSSION

We compared the results of a traditional FA with those of the IISCA with five consecutive participants who had been referred for the assessment and treatment of severe problem behavior to test the assumptions associated with each approach. Four of the five participants showed a response pattern consistent with the assumption of the traditional FA that the putative contingencies (and corresponding EOs) for problem behavior primarily act independently to reinforce problem behavior (e.g., the EOs and contingencies for attention act independently of the EOs and contingencies for escape). None of the five participants showed a response pattern consistent with the assumption of the IISCA that the putative contingencies (and corresponding EOs) for problem behavior primarily act in combination (or interactively) to reinforce problem behavior (e.g., the assumption that the EOs and contingencies for tangible items interact with the EOs and contingencies for escape to produce a differential effect). Finally, one of the five participants displayed no problem behaviors during either the traditional FA or the IISCA.

The traditional FA assessed putative reinforcement contingencies individually and demonstrated that problem behavior was sensitive to at least one of the individual contingencies tested with four of the participants. Those same four participants also showed differentiated responding between the synthesized test and control conditions of the IISCA. However, comparisons of the results of the traditional FA and IISCA revealed no evidence of interaction effects between the individual contingencies when we combined those contingencies during the IISCA. That is, the synthesized contingencies of the IISCA did not produce more robust reinforcement effects than the relevant individual contingencies of the traditional FA. For example, Cameron displayed equivalent levels of problem behavior when this response produced only tangible reinforcement during the traditional FA as when it produced the combination of tangible items and escape during the IISCA. Thus, for this participant, the escape contingency that we included in the synthesized contingency of the IISCA appeared to be irrelevant to the function of problem behavior (i.e., the tangible item reinforced problem behavior equally well with and without the escape contingency).

Comparisons between the results of the traditional FA and IISCA showed that the IISCA included functionally irrelevant contingencies for all four participants for whom we observed differentiated responding during the traditional FA and IISCA.

The IISCA identified three operant functions of problem behavior (attention, tangible, and escape) for three of the participants, two operant functions of problem behavior (tangible and escape) for one participant, and no operant function for the remaining participant. Comparisons between the results from the traditional FA and IISCA confirmed the results of the IISCA only for this participant. That is, the two analyses agreed that this participant's problem behavior was not sensitive to attention, tangible items, or escape as reinforcement in a clinic setting when we evaluated those contingencies individually or as components of a synthesized contingency. For the other four participants, comparisons between the traditional FA and IISCA results showed that the IISCA included one functionally irrelevant contingency for two participants (Alan and Cameron) and two functionally irrelevant contingencies for the other two (Allie and Tina).

When we compared the results of components used to develop the IISCA with the results of the traditional FA and IISCA, the open-ended interview implicated more functionally irrelevant contingencies (64%) than functionally relevant contingencies (36%). In addition, the structured observation implicated about the same percentage (30%) of functionally irrelevant contingencies as functional relevant contingencies (30%), but it also missed one functionally relevant contingency (i.e., the tangible function for Tina).

Several researchers have examined the predictive validity of indirect functional assessments by comparing the results of these measures with the findings of a traditional FA, and the results have typically yielded unacceptably low levels of agreement between the two approaches (e.g., Newton & Sturmey, 1991; Paclawskyj, Matson, Rush, Smalls, & Vollmer, 2001; Zarcone, Rodgers, Iwata, Rourke, & Dorsey, 1991). The results of studies that have examined the predictive validity of direct assessments using traditional FAs as the criterion variable have produced similarly disappointing results (e.g., Lerman & Iwata, 1993; Piazza et al., 2003; St. Peter, Vollmer, Bourret, Borrero, & Sloman, 2005; Thompson & Iwata, 2007). The IISCA represents a unique departure from these prior studies in that it uses an open-ended interview and informal observations to design and individualize an efficient FA, an approach that has proven to be useful for identifying idiosyncratic functions after a traditional FA produced inconclusive results (e.g., Bowman et al., 1997; Roscoe et al., 2015). Thus, it seems reasonable to examine whether behavior analysts could use the results of indirect and direct functional assessments on the front end, before any experimental manipulations, to design more individualized and accurate FAs. Unfortunately, with the current participants, the IISCA was no more accurate than other approaches that rely heavily on the results of indirect and direct assessments. That is, the individualized IISCA that we developed from the indirect and direct measures produced no appreciable improvements in predictive validity over levels of convergence with a traditional FA observed in prior studies (e.g., Lerman & Iwata, 1993; Paclawskyj et al., 2001; Thompson & Iwata, 2007; Zarcone et al., 1991). Similar to the results of direct assessment methods, the open-ended interview and structured observations most often erroneously implicated contingent attention as a reinforcer for problem behavior (Thompson & Iwata, 2001, 2007).

Overall, we observed low levels of agreement between the IISCA and the traditional FA, regardless of whether we used the results of the open-ended interview, the structured observations, or the overall IISCA. Moreover, we attempted to find ways to use the results of the open-ended interview and structured observation to improve the levels of convergence with the traditional FA without much success. For example, we asked, “What if we only included reinforcers in the synthesized contingency implicated by both the open-ended interview and the structured observation?” Analysis and interpretation of the data in this manner did not appreciably alter the levels of agreement with the traditional FA.

One possible advantage of the IISCA over a traditional FA is that the former may have increased ecological validity because it uses the open-ended interview to tie the contingencies included in the synthesized contingency to ones that are purported to operate in the natural environment for each individual. However, the current results provide little evidence for the increased ecological validity of the IISCA. In fact, in the current investigation, the open-ended interview and structured observation had only a slight differential effect on the reinforcers that we included in the synthesized contingency of the IISCA. For four of the participants, we included attention, tangible items, and escape, and for the remaining participant (Cameron), we included tangible items and escape. Thus, if we had not conducted the interview and observation and simply tested a synthesized contingency that involved all of the typical putative reinforcers reported in the literature (attention, tangible items, and escape) with all participants, we would have produced highly similar results. If we had used this alternative contingency synthesis approach (i.e., combining attention, tangible items, and escape into a single contingency with every participant), we would have included one additional functionally irrelevant contingency (attention for Cameron) relative to the IISCA and produced one less missed function (i.e., we would have included the tangible function that was missed by the structured observation conducted with Tina). We also would have saved the roughly 50 min per participant that the open-ended interviews and structured observations required.

Jessel et al. (in press) suggested that the IISCA might have advantages over other forms of FA in terms of safety (e.g., reduced exposure to EOs). We found no differences between the analyses regarding the safety of the participants in the current investigation. None of the participants experienced injuries, minor or otherwise, during either analysis. Our results are in general agreement with Kahng et al. (2015), who found similar levels of injury from SIB during traditional FAs as during other times of the day outside the FA sessions.

We caution practitioners who wish to incorporate the IISCA into their clinical practice due to its simplicity and efficiency, given the questions regarding its validity raised by the results of the current investigation. Clearly, researchers should collect additional data on the levels and types of convergence and divergence between the IISCA and the traditional FA with more participants before drawing firm conclusions regarding the validity of the IISCA. Nevertheless, we are concerned that clinicians may derive a false sense of confidence from the experimental analysis component of the IISCA because it rapidly and consistently produces clearly differentiated responding between the synthesized test and control conditions. As mentioned above, practitioners would likely produce similarly rapid and consistent levels of experimental differentiation simply by including the three most common

reinforcers for problem behavior (attention, tangible, and escape) in every synthesized contingency analysis, but doing so will also produce inaccurate information about which contingencies reinforce problem behavior and which ones do not.

Inclusion of both functional and irrelevant consequences in a synthesized contingency may create potential problems. It ostensibly leads to more complex and labor-intensive interventions (e.g., delivery of multiple consequences when just one is sufficient). Moreover, delivery of escape either contingent on an alternative response or on a time-based schedule when tangible items (or attention) exclusively reinforce problem behavior will necessarily result in less academic instruction or work for the individual.

We do not suggest that we found no value in the open-ended interview or the structured observation. We believe that open-ended interviews provide structure and greater technological rigor than many previous studies that have used indirect measures to develop idiosyncratic FAs following inconclusive traditional FAs (e.g., Bowman et al., 1997; Fisher, Lindauer, Alterson, & Thompson, 1998). In addition, we believe that we have described the structured observation procedure that we used in the current study in clear and operational terms that will facilitate replication of the procedures by future researchers, whereas most prior studies have outlined less formal observation procedures (e.g., Fisher, Adelinis, et al., 1998; Hanley et al., 2014). In fact, the structured observations in the current study might represent a preliminary FA because we systematically manipulated putative reinforcement contingencies and measured their effects.

Prior research supports these types of indirect and direct assessments for designing idiosyncratic FAs following inconclusive traditional FAs (e.g., Bowman et al., 1997). The current findings raise doubts regarding whether behavior analysts should use indirect and direct assessments to develop synthesized test conditions before they test general reinforcement contingencies (e.g., positive, negative, and automatic reinforcement) individually with a traditional FA. Future researchers should conduct additional within-subject comparisons of the IISCA and traditional FA with larger cohorts of participants to provide a more definitive evaluation of the strengths and limitations of the IISCA.

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Figure 1. Hypothetical data patterns showing independent effects (top panel), interactive effects (second panel), independent and interactive effects (third panel), and no effects (bottom panel) of individual and synthesized contingencies.

Figure 2.

Responses per minute of problem behavior across traditional functional analysis (FA) and the interview-informed synthesized contingency analysis (IISCA) for Alan, Allie, and Cameron. We replaced Alan's initial tangible items with an iPad beginning in Session 31.

Figure 3. Responses per minute of problem behavior across the interview-informed synthesized contingency analysis (IISCA) and traditional functional analysis (FA) for Sylvia and Tina.

Table 1

Demands and Materials Used in the IISCA and FA Conditions

	Demands in IISCA (test condition)	Demands in FA (escape condition)	Tangible items in IISCA (test condition)	Tangible items in FA (tangible condition)
Alan	Shape sorting, dressing and undressing	High-preference: shape sorting; low-preference: dressing and undressing	Trucks, backpack, iPad, squish toy, Play-Doh	Trucks, backpack, iPad
Allie	Brushing hair, gross-motor activities, receptive identification	Brushing hair, gross-motor activities, receptive identification	iPad	iPad
Cameron	Cleaning, receptive identification, dressing or undressing	Cleaning, receptive identification, building	iPad	iPad
Sylvia	Academic worksheets, cleaning, folding laundry, picking up toys	Academic worksheets, cleaning, folding laundry, picking up toys	iPad, Play-Doh, journal	iPad, Play-Doh, journal
Tina	Cleaning, brushing hair	Cleaning, brushing hair, academic worksheets	Light-up ball, Play-Doh, books	Light-up ball, Play-Doh, books

Note. Half of the escape sessions of Alan's FA included high-preference demands, and the other half included low-preference demands.

Data from sessions with high-preference demands are not presented but are available from the corresponding author.

Table 2

Comparative Results of the Open-Ended Interview, Structured Observations, IISCA, and Traditional FA

Participant	Open-ended interview	Structured observation	IISCA	Traditional FA
Alan	Attention , tangible, escape	Attention , tangible, escape	Differentiated, without individual or interaction effects	Tangible, escape
Allie	Attention , tangible, escape	Attention , tangible, escape	Differentiated, without individual or interaction effects	Tangible
Cameron	Tangible, escape	Tangible or tangible and escape	Differentiated, without individual or interaction effects	Tangible
Sylvia	Attention , tangible , escape	No problem behavior observed	No problem behavior observed	No problem behavior observed
Tina	Attention , tangible, escape	<i>No problem behavior observed</i>	Differentiated, without individual or interaction effects	Tangible

Note. Functionally relevant stimuli identified during the open-ended interview and structured observation are presented in regular typeface, irrelevant stimuli are in boldface type, and missed functions are in italics.