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INTERVIEW-INFORMED FUNCTIONAL ANALYSES: A COMPARISON OF SYNTHESIZED AND ISOLATED COMPONENTS

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Hanley, Jin, Vanselow, and Hanratty (2014) described a functional analysis (FA) format that relied on a synthesis of multiple contingencies described by caregivers during open-ended interviews. These interview-informed synthesized contingency analyses (IISCA) provided effective baselines from which to develop socially validated treatments, but the synthesis precluded a precise understanding of individual contingencies influencing problem behavior. We conducted IISCAs and standard FAs (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994) for nine children with autism to evaluate the likelihood of differentiation given a number of synthesized versus isolated variables. The IISCA was differentiated for all. The standard FA was differentiated for four; this number increased to six when we included precursors in the standard FA. We then compared treatments based on sets of differentiated analyses for four children. Treatment based on the IISCA was effective for all four; treatments based on the standard FA were effective for two. The role of synthesis in analysis is discussed.

Key words: autism, functional analysis, functional communication training, IISCA, problem behavior, synthesized analysis

Functional analysis (FA) is the most widely researched method for assessing problem behavior of individuals with developmental disabilities and is a vital component in developing effective treatments for these individuals (Beavers, Iwata, & Lerman, 2013; Hanley, Iwata, & McCord, 2003). Because the FA allows for the detection of relevant establishing operations (EOs) that evoke the problem behavior as well as the reinforcers that maintain it, treatments for problem behavior that are developed from an FA are more likely to be effective (Campbell, 2003) and less likely to rely on punishment (Kahng, Iwata, & Lewin, 2002; Pelios, Morren, Tesch, & Axelrod, 1999). Information obtained from an FA may then be integrated into a treatment such as functional communication training (FCT), in which the identified reinforcers are delivered contingent on an appropriate communication response (e.g., Carr & Durand, 1985; Fisher et al., 1993; Tiger, Hanley, & Bruzek, 2008).

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In their seminal article, Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) described an FA that used a multielement design to compare test conditions for each of the most commonly suspected operant classes of problem behavior (automatic reinforcement, socially mediated positive reinforcement, socially mediated negative reinforcement). Reviews of the FA literature by Hanley et al. (2003) and Beavers et al. (2013) indicate that most examples of published FAs share a number of features in common with the analysis described by Iwata et al. (1982/1994). For example, Beavers et al. reported that 80% of FAs used a multielement design, 90% had multiple test conditions, over 90% used the ABC model in which consequences are provided for target behaviors in each test condition, over 90% included a test for socially mediated positive reinforcement, over 90% included a test for socially mediated negative reinforcement, and over 50% included a test for automatic reinforcement. These percentages are similar to those reported by Hanley et al. (2003). Given that the majority of published FAs include these common features, it seems reasonable to describe an analysis with these features as a *standard FA*. This does not mean that FA as a methodology is or should be standardized; in fact, FA is a powerful and flexible tool that can be adapted to fit a variety of research or clinical needs (Hanley, 2012; Iwata & Dozier, 2008). However, the term *standard FA* is a convenient way to tact the particular type of FA that is most frequently reported in the literature, and we use this term to refer to such FAs throughout the rest of the article.

Iwata and Dozier (2008) summarized a number of modifications to standard FA procedures that have been reported over the past few decades, each of which they described as best suited to a particular set of circumstances. When there are very few constraints to the assessment process, these authors recommend what they term a "full FA," characterized by repeated measures of problem behavior across multiple test conditions (i.e., a standard FA). However, when limited assessment time is a concern, a brief FA with only one session per condition may be conducted (e.g., Derby et al., 1992; Northup et al., 1991). When high-risk behavior is a concern, a latency FA may be conducted in which the session is terminated after the first response (e.g., Thomason-Sassi, Iwata, Neidert, & Roscoe, 2011) or a precursor FA may be conducted in which reinforcement contingencies are applied to behaviors that tend to precede the high-risk behavior (e.g., Borrero & Borrero, 2008; Fritz, Iwata, Hammond, & Bloom, 2013; Herscovitch, Roscoe, Libby, Bourret, & Ahearn, 2009; Langdon, Carr, & Owen-DeSchryver, 2008; Smith & Churchill, 2002). These formats are presented as alternatives to the standard FA.

A different type of concern, however, is how to proceed when a standard FA has been conducted and is inconclusive. Modifications that deviate more substantially from a standard FA may be necessary when inconclusive results are obtained, although it is unclear how often this may occur. As one example, Hagopian, Rooker, Jessel, and DeLeon (2013) reported the outcomes of 176 FAs that were selected using "a consecutive case-series design … to minimize any potential selection bias favoring particular outcomes" (p. 91). Of the standard FAs that met their inclusion criteria, 53% (94 of 176) were undifferentiated on the first attempt. These results should be interpreted with caution because they were drawn from a population of individuals on an inpatient unit for the treatment of severe problem behavior, and such a sample may not be representative of the larger population of individuals who engage in problem behavior. However, these data are important because the authors reported the number of iterations required before an FA was differentiated. Other large *n* studies (e.g., the epidemiological study by Iwata, Pace, et al., 1994) report only the final iteration of the FA,

making it unclear the extent to which a standard FA is likely to be differentiated on the first attempt. The data reported by Hagopian et al. suggest that a standard FA may often need to be modified to obtain conclusive results. Continuing to evaluate FA modifications and their likelihood of differentiation is therefore an important line of inquiry.

One such possible modification is to combine idiosyncratic reinforcers in a single test condition. For example, Bowman, Fisher, Thompson, and Piazza (1997) reported an FA with a single test condition in which the participant's mands were reinforced contingent on destructive behavior. In a second example, Fisher, Adelinis, Thompson, Worsdell, and Zarcone (1998) described an FA with a single test condition in which problem behavior produced escape from the analyst's prompts and interruptions plus access to resuming the ongoing activity in which the participant had been engaged. In a recent review, Schlichenmeyer, Roscoe, Rooker, Wheeler, and Dube (2013) described idiosyncratic variables that have been evaluated in FAs. These authors identified 42 studies published between 2001 and 2010 in which the standard FA was modified to include participant-specific rather than generic variables. Some examples of idiosyncratic EOs included manipulating the type of prompting for a task (Tiger, Fisher, Toussaint, & Kodak, 2009), having the analyst engage with the participant's preferred items (Kuhn, Hardesty, & Luczynski, 2009), or manipulating the level of social attention (Call, Wacker, Ringdahl, Cooper-Brown, & Boelter, 2004). Some examples of idiosyncratic reinforcers included a specific type of attention (Kodak, Northup, & Kelley, 2007), access to ritualistic behaviors (Falcomata, Roane, Feeney, & Stephenson, 2010), or engaging in preferred conversations (Roscoe, Kindle, & Pence, 2010). The examples reviewed by Schlichenmeyer et al. are important because they demonstrate the value of considering individualized variables in FAs and the successful modification of the standard FA with the inclusion of idiosyncratic variables.

Hanley et al. (2014) reported a set of substantial modifications to the standard FA that included many of the variations described above. These authors used an open-ended interview (see Hanley, 2012) to identify reinforcers suspected of influencing problem behavior, and these reinforcers were then synthesized in one test condition that emulated a naturally occurring context in which problem behavior was reported to occur. This synthesized test condition was compared to a matched control condition in which all putative reinforcers were continuously available. This type of analysis has since been described as an interview-informed synthesized contingency analysis or IISCA (Ghaemmaghami, Hanley, & Jessel, 2016; Ghaemmaghami, Hanley, Jin, & Vanselow, 2015; Jessel, Hanley, & Ghaemmaghami, 2016). The IISCA packages multiple FA modifications that have been reported separately by several authors: (a) a single test condition rather than multiple test conditions (e.g., Adelinis & Hagopian, 1999; Bowman et al., 1997; Fisher et al., 1998); (b) combined rather than isolated reinforcers (e.g., Kuhn, Hardesty, & Sweeney, 2009; Leon, Lazarchick, Rooker, & DeLeon, 2013; Mann & Mueller, 2009; Mueller, Sterling-Turner, & Moore, 2005; Payne, Dozier, Neidert, Jowett, & Newquist, 2014; Rispoli, Camargo, Machalicek, Lang, & Sigafoos, 2014; Sarno et al., 2011; Zarcone, Fisher, & Piazza, 1996); (c) idiosyncratic rather than generic EOs and reinforcers (see Schlichenmeyer et al., 2013, for a review); (d) shorter session duration (Wallace & Iwata, 1999); (e) reinforcing co-occurring topographies of problem behavior (e.g., Lalli, Mace, Wohn, & Livezey, 1995; Magee & Ellis, 2000; Richman, Wacker, Asmus, Casey, & Andelman, 1999); and (f) reinforcing precursors to problem behavior (e.g., Borrero & Borrero, 2008; Langdon et al., 2008; Smith & Churchill, 2002). None of the components included in the IISCA

are novel in and of themselves; each has precedent in the FA literature. The combination of these particular modifications is novel and has produced highly effective treatments (Ghaemmaghammi et al., 2016; Ghaemmaghami et al., 2015; Hanley et al., 2014; Santiago, Hanley, Moore, & Jin, 2016; Strohmeier, Murphy, & O'Connor, 2016). However, because multiple variables are synthesized in the IISCA, the relevance of each variable in any demonstrated functional relation is unclear.

The IISCA synthesizes each component of the three-term contingency: antecedents (EOs), behaviors (response topographies), and consequences. *Establishing operations* are synthesized by presenting multiple evocative events at once, such as restricting access to tangible items while presenting demands. *Response topographies* are synthesized by including precursor responses and co-occurring topographies of problem behavior in the contingency class. For example, if foot stomping is reported to occur shortly before bouts of self-injury and aggression, any of those three responses would be reinforced during the IISCA test condition. The inclusion of precursors has been reported by other authors who have conducted an IISCA (see Jessel et al., 2016) and is one of its characteristic features. *Consequences* are synthesized based on reports of outcomes that tend to occur together following problem behavior. For example, for participant Gail in Hanley et al. (2014), Gail's mother reported providing her with preferred toys and undivided attention to redirect the problem behaviors of screaming, throwing items, and aggression. Gail's test session therefore involved the provision of both tangible items and high-quality attention for any instance of screaming, throwing items, or aggression.

Synthesizing or isolating different components of contingencies offers different types of precision in an FA. Providing a single reinforcer for a single topography of problem behavior in each test condition can offer precision in identifying the individual impact of each reinforcer suspected of influencing a particular problem behavior. Combining variables that are reported to occur together can offer precision in emulating the natural contexts in which problem behavior typically occurs. At present, we do not know the relative advantage of these two types of precision in analyzing and treating problem behavior. For example, are we more likely to obtain a differentiated analysis and develop an effective treatment by precisely isolating each response–reinforcer relation, or by precisely replicating the contexts under which problem behavior occurs in the natural environment? One way to begin answering these questions may be to compare outcomes from IISCAs to outcomes of standard FAs to determine whether both analyses are differentiated, whether they suggest different reinforcers for problem behavior, and whether subsequent treatments based on both analyses are effective.

Fisher, Greer, Romani, Zangrillo, and Owen (2016) reported data for five participants with whom they conducted an IISCA and standard FA. Both analyses were differentiated for four out of five participants; the fifth participant did not engage in any problem behavior in either analysis. For cases in which both analyses were differentiated, the standard FA detected one or two of the same reinforcers that had been synthesized in the IISCA. For example, for participants Allie and Tina, the IISCA combined the reinforcers of escape, attention, and tangible items; their standard FAs were differentiated for tangible items. The data reported by Fisher et al. (2016) indicate that the IISCA and standard FA are both likely to be differentiated and likely to detect some (though not all) of the same reinforcers for problem behavior. Additional within-participant comparisons of the IISCA and standard FA are needed for several reasons. First, Fisher et al. (2016) represents the only comparative evaluation of the IISCA and standard FA thus far, and it is therefore difficult to speak to the generality of the

outcomes they obtained. Second, a comparative treatment analysis was not included in that study, which means there are currently no data available regarding the relative efficacy of treatments based on the IISCA and other FA formats. Because the primary purpose of an FA, especially in practice, is to obtain information that can be used to develop an effective treatment for problem behavior, it is particularly important to know whether the IISCA yields treatments that are equally as effective as treatments based on other FA formats. We therefore compared outcomes of IISCAs to outcomes of standard FAs for nine children with autism (Study 1), and then compared outcomes of IISCA-based treatment to outcomes of standard FA-based treatment for a subset of those same children (Study 2).

STUDY 1: COMPARISON OF IISCA AND STANDARD FA

The purpose of Study 1 was to compare the IISCA and the standard FA to determine relative probability of differentiated outcomes. We conducted this comparison with nine children with autism, and we implemented each analysis format the way each has been reported most often in the literature. Based on descriptions provided by Hanley et al. (2014) and Jessel et al. (2016), the IISCA therefore included the following features: a single test condition and matched control condition developed from an open-ended interview, a synthesis of idiosyncratic EOs in the test condition, a synthesis of idiosyncratic reinforcers provided contingent on precursor *or* problem behavior in the test condition, and the use of a multielement design to compare test and control conditions. Based on methods described by Iwata et al. (1982/1994) and data and practice recommendations provided by Beavers et al. (2013), Hanley et al. (2003), and Iwata and Dozier (2008), the standard FA included a multielement design with separate test conditions for attention, tangible items (when suggested by caregiver interview), escape, and automatic reinforcement, and a generic toy-play control condition. The contingency in each test condition was applied to co-occurring topographies of problem behavior but not to precursors, as Beavers et al., Hanley et al., and Iwata and Dozier all describe a precursor FA as a modification to the standard FA rather than a characteristic feature of it. It should be noted, however, that if precursor responses and problem behavior occurred simultaneously or within seconds of each other (e.g., whining while engaging in SIB), the precursor response contacted reinforcement by virtue of its close temporal proximity to problem behavior. If the only responses observed during the standard FA were precursors (i.e., no problem behavior occurred), we then conducted a precursor FA as a third analysis. In summary, Study 1 compared the IISCA package as it has been most recently described to the standard FA as it has been most frequently described, with the use of one modification to the standard FA (a precursor FA) when applicable. Variables such as session duration, analyst, specific tangible items, specific demands, and specific types of attention were held constant across both analyses.

Participants experienced the IISCA first and then the standard FA. We chose not to counterbalance the order of FA formats across participants because this tactic would not necessarily eliminate sequence effects (see Higgins Hains & Baer, 1989). Instead, the order of IISCA first and standard FA second was arranged to capitalize on a potential sequence effect: exposure to some of the contingencies in the first analysis could make it more likely that the second analysis may be differentiated. We chose to give this potential advantage to the standard FA. In addition, when evaluating new FA formats, there is precedent for conducting the new format first and then comparing results to those from a standard FA (e.g., Bloom, Iwata, Fritz,

Roscoe, & Carreau, 2011; Langdon et al., 2008; Thomason-Sassi et al., 2011).

After obtaining differentiation in the IISCA and then experiencing the same number of test sessions in the standard FA, there were four possibilities for the participant: (a) if problem behavior occurred in the standard FA and was differentiated, participation in Study 1 was complete; (b) if problem behavior occurred in the standard FA but was not yet differentiated, we conducted one or two more series of conditions to determine if responding would differentiate with further analysis; (c) if no problem behavior occurred in the standard FA but precursors did occur, we conducted a precursor FA to determine the effects of the standard FA contingencies on precursor responses that had been reinforced in the IISCA; and (d) if no problem behavior *or* precursors occurred in the standard FA, we replicated the IISCA to verify that the functional relation it had initially detected was still operating.

Method

Participants and setting. Participants were children who attended a private day school for individuals with autism. Clinical teams at the school were informed that the first author would be conducting a study on different FA formats and were asked if they had any clients for whom they would like assistance in treating problem behavior. Participants were therefore nominated by their clinical teams based on the need for treatment of problem behavior, rather than selected by the authors. The participants in Study 1 represent the first nine children referred to the study; this study therefore conforms to the requirements of a consecutive controlled case series design (Hagopian et al., 2013). These participants either had a history of failed analysis or treatment attempts, or had recently displayed some change in problem behavior such as new topographies or an increase in frequency. Problem behavior significantly restricted involvement in educational and community activities for all participants. All participants engaged in topographies of problem behavior that could produce bruises or abrasions to themselves or others; seven participants had treatment plans that included emergency measures such as protective equipment, physical restraint, or exclusionary timeout; four participants were unable to attend school field trips or outings because of the chance that problem behavior may occur in the community; four participants were taking medications to address problem behavior; one participant was often an hour late to school because of problem behavior during his morning routine at home.

All participants had a primary diagnosis of autism; one participant had an additional diagnosis of Landau-Kleffner Syndrome (LKS), and one participant had an additional diagnosis of a tic disorder. Participants ranged in age from 7 to 18 years old, and included seven boys and two girls. The primary mode of communication for participants included vocal speech or the use of speech-generating devices (SGDs) such as iPads™. Participants were reported to engage in a variety of problem behaviors: aggression, SIB, disruption, eloping, flopping, climbing on furniture, and screaming. See Table 1 for more details regarding participant characteristics.

Sessions were conducted in a 3.5 x 3.5 m room (Chloe, Diego, Dylan, Jeff, Jonah, Kyle, and Riley) or the participant's classroom (Emily, Mason). Session rooms were equipped with a table, chairs, a bookshelf, a small beanbag, and a soft mat. Participant-specific materials were added as applicable (e.g., specific toys, books, electronics). Classrooms were approximately 6 x 6 m and included individual workspaces for three or four students, with each workspace consisting of a desk and two chairs, small bookshelves, and drawers with teaching materials.

Response definitions, measurement, and interobserver agreement (IOA). Sessions were

Table 1
Participant Characteristics

Participant	Age	Sex	Diagnosis	Language Ability[a]	Communication Mode	Problem Behavior
Diego	11	M	Autism	3	Vocal	Aggression, SIB, disruption
Mason	10	M	Autism	4	Vocal	Aggression, disruption
Riley	12	M	Autism	3	Vocal, SGD	Aggression, SIB, disruption
Kyle	17	M	Autism, tic disorder	3	SGD	Aggression, SIB
Jonah	7	M	Autism	2	SGD	Eloping, flopping and hiding, climbing
Emily	13	F	Autism	4	Vocal	Aggression, SIB, screaming
Jeff	18	M	Autism, LKS	2	Vocal, SGD	Aggression, SIB, disruption, flopping
Dylan	7	M	Autism	3	Vocal	Aggression, disruption
Chloe	14	F	Autism	3	Vocal	Aggression, SIB

Note. SGD = speech generating device; SIB = self-injurious behavior; LKS = Landau-Kleffner syndrome
[a] 1 = no independent communication; 2 = single-word utterances; 3 = short sentences; 4 = full fluency

recorded using a camcorder or similar equipment, and data were collected using laptop computers with data collection and analysis software. We scored each instance of problem behavior and precursor behavior, as well as the onset and offset of each reinforcement interval. From these data, we calculated rate of problem behavior, rate of precursors, and the conditional probability of a precursor response contacting reinforcement within 2 s during the standard FA. We report problem behavior and precursors as responses per min. In general, *problem behavior* consisted of the specific behaviors for which the participant had been referred (e.g., aggression, SIB, disruption). Topographies of aggression included grabbing, pinching, scratching, hitting, biting, kicking, pulling hair, and head butting. Topographies of SIB included hand-to-head, head-to-object, and self-biting. Topographies of disruption included throwing work materials or toys, throwing furniture, or ripping and destroying materials. Flopping was defined as dropping to the floor from a standing position or from a seated position; eloping was defined as running more than two steps away from the teacher (in an open space) or pushing down the door handle and attempting to leave the room (in a closed room). *Precursors* were responses that had been reported to precede problem behavior (e.g., grimacing and clenching teeth before engaging in aggression) and were defined individually by participant. A response was included as a precursor if the team reported that it tended to occur right before problem behavior and did not tend to occur at other times in the absence of problem behavior. See Table 2 for a list of the specific problem and precursor behaviors reported for each participant.

IOA was assessed by having a second observer independently score at least 20% of sessions (range, 20%–67%) in each condition of each analysis for each participant. Agreement was calculated by dividing sessions into 10-s intervals and dividing the number of agreements per interval by the number of disagreements plus agreements per interval and multiplying by 100. Mean IOA was 97% (session range, 80%–100%).

Experimental design. We used a multielement design to compare conditions within each analysis. Sessions were 3 min (Chloe, Riley), 5 min (Diego, Dylan, Emily, Jonah, Kyle, Mason), or 10 min (Jeff). Session duration was determined in advance based on staff input and was held constant across analyses. For example, staff reported that Jeff very frequently worked for periods of 5 min or longer without problem behavior, and that problem behavior was more likely to occur as his work task approached 10 min in duration or when he was required to

Table 2
Topographies of Problem Behavior and Precursors

Participant	Problem Behaviors (reported to occur together)	Precursor(s)
Diego	Hitting, kicking, or head butting others; throwing furniture and other objects; head-to-object SIB	Screaming
Mason	Hitting or kicking others; hitting or throwing objects	Whining; grimacing; body slam in chair
Riley	Hitting, kicking, or biting others; pulling hair; hand-to-head SIB; throwing objects	Whining; body tensing
Kyle	Grabbing others; hand-to-head SIB	Whining; biting lip
Jonah	Eloping; flopping and hiding (flop plus legs or shoulders under an object); climbing on furniture	*None reported*
Emily	Grabbing, scratching, or charging at others; biting self; head-to-object SIB; screaming	Whining; clenching teeth; sudden body jerks
Jeff	Grabbing or pushing others; biting self; ripping materials; flopping (kneeling or laying on ground)	"Nooo!" in high-pitched voice
Chloe	Grabbing or pushing others; hand-to-head SIB	Screaming
Dylan	Hitting, kicking, or charging at others; throwing objects at others	Yelling "ASHHH!"

do more than one task in a row. We therefore set Jeff's sessions at 10 min. Staff reported that Chloe immediately became agitated the moment anyone attempted to help her put on her shoes, which is a very short task. We therefore set Chloe's sessions at 3 min.

Procedures

Open-ended interview. Open-ended interviews can be helpful in gathering information that may then be more formally and systematically evaluated (e.g., Hanley et al., 2014; Hawkins, 1979; Iwata, Wong, Riordan, Dorsey, & Lau, 1982). We interviewed each participant's Board Certified Behavior Analyst (BCBA) and at least one other staff member who worked directly with the participant. Each interview was approximately 30 min and involved some form of the questions from the open-ended functional assessment interview provided in the appendix of Hanley (2012). Additional clarifying questions were asked as necessary. Because the standard FA for each participant included the same tangible items, demands, and types of attention that were synthesized in the IISCA, both analyses were therefore informed by the interview to some extent. However, the interview was more intimately tied to the IISCA in that the IISCA used the particular stimuli reported in the interview to emulate the combination of EOs and consequences that were also reported. By contrast, the role of the interview in the standard FA was to select stimuli with which to populate otherwise generic test conditions whose contingencies were already determined.

Multiple informants were interviewed because the structure of the school program was such that different staff interacted with the participant in different contexts, and therefore may have had different information to share. We conducted one interview with all informants at the same time for the sake of efficiency, and so informants could add to each other's reports. The smallest group of informants for any participant was two; the largest group was five. We searched for discrepancies between informant reports not because we were concerned with inter-informant reliability, but because we wanted to include the most potentially evocative situations and reinforcing consequences that were relevant to the participant. For example, if one person reported that math tasks tended to evoke problem behavior but another person insisted that daily living tasks were most problematic, we would ask additional questions such as how quickly each task seemed to evoke problem behavior, which task seemed to evoke

more dangerous topographies, which task was of greatest concern to the team and family, and whether the discrepant reports may be occurring because the informants interact with the participant in different contexts. Rather than viewing these discrepancies as indicating poor reliability of the interview, we viewed them as reflective of the fact that problem behavior occurs in many different contexts, and we used follow-up questions to narrow down which specific context may be most relevant and practical to include in the analysis.

IISCA. The control condition for each participant included continuous access to the multiple putative reinforcers arranged in the test condition, thereby eliminating any EO for these reinforcers. Problem behavior or precursors in the control condition produced no programmed stimulus change. It is important to note that to be included in the analysis, putative reinforcers must have been reported in the interview as sometimes following problem behavior. In other words, we carefully combined potential reinforcers based on informant report. We also carefully excluded stimuli based on informant report. For example, attention in the form of praise is often delivered on a fixed schedule during FA control conditions. However, if attention was not one of the reinforcers specifically being evaluated in the IISCA test condition, we did not include it in the control condition. We responded to any social bids that the participant initiated, but we did not otherwise attend to him or her and never provided any unsolicited attention. The test condition contained the multiple EOs reported to evoke problem behavior, and the occurrence of problem behavior or precursors produced 30 s of access to the multiple putative reinforcers.[1] With one exception, the sequence of conditions for all participants was control, test, control, test, test.[2] We selected this sequence because alternating between control and test conditions for two sessions of each provided the minimum data necessary to demonstrate a functional relation; adding a third test session then provided three data points to be used as a baseline from which to evaluate treatment. Contingencies in the IISCA test condition were unique to each participant (i.e., the open-ended interviews did not yield the same suspected combination of stimuli for any two participants). Contingencies included escape from a handwriting task to toys and attention (Diego); escape from a reading task to toys, preferred conversations, and answers (Mason); escape from medicine presentation to YouTube (Riley); escape from an unpredictable to a predictable schedule (Kyle); escape from independent leisure tasks to toys, attention, and stereotypy (Jonah); escape from medical demands to toys (Dylan); escape from reading and daily living tasks to music and child-directed interaction (Emily); escape from a dressing task to rituals (Chloe); escape from vocational work to YouTube (Jeff). See Table 3 for a summary of the control and test conditions of each individual IISCA.

Standard FA. The standard FA for each participant included the following conditions: alone or ignore, attention, tangible (except Chloe), escape, and play. These conditions were similar to those described by Iwata et al. (1982/1994) and were implemented in a fixed sequence as described by Iwata, Pace, et al. (1994) to capitalize on EOs present across sessions (e.g., experiencing the alone condition first may establish the value of attention as a reinforcer). As many variables were held constant between the IISCA and standard FAs as possible: session duration, analyst, type of

[1] In other words, the 30-s reinforcement interval in each participant's test condition was *identical* to his or her control condition.

[2] In Jeff's case, because only one instance of problem behavior occurred during his first test session, we continued alternating for a total of three control and four test sessions to confirm that a functional relation was indeed present.

Table 3
IISCA Test and Control Conditions

Participant	Control Condition (and test condition reinforcement)	Test Condition (establishing operation)
Diego	Read out loud to Diego and provide access to preferred toys, with no handwriting demands presented	Stop reading to Diego; instruct him to put down toys and come do handwriting
Mason	Give Mason his toys and respond to any conversation topics he initiates; answer any questions he asks	Remove toys and instruct Mason to come do a reading task. Present words to read and do not otherwise interact with Mason.
Riley	Allow Riley to watch YouTube; do not present medicine	Pause YouTube and instruct Riley to take his medicine
Kyle	Allow Kyle to follow his schedule of preferred activities; do not change or interrupt his schedule	Interrupt Kyle's schedule of preferred activities and present a difficult task (counting money) that is not on his schedule
Jonah	Let Jonah go to his "fun space" to run around and tap things; provide undivided attention and eye contact	Instruct Jonah to leave his "fun space" (empty room where he can run around and tap things) and come put together a puzzle at his desk
Emily	Turn on music and allow Emily to direct all interactions (e.g. repeat phrases for her or re-enact mistakes as directed). Do not speak unless Emily speaks first.	Turn off music, instruct Emily to brush hair or pack up her backpack while correcting and physically prompting her
Jeff	Allow Jeff free access to YouTube and do not present any demands	Pause YouTube and instruct Jeff to engage in vocational counting and packaging task
Chloe	Allow Chloe to put on / remove shoes her own way without interrupting any ritualistic behavior	Interrupt shoe ritual and help Chloe put on / remove shoes
Dylan	Allow Dylan free access to his toys and do not try to take his temperature	Tell Dylan it's time to stop playing with toys and get his temperature taken

attention, specific tangible items, and specific demands.

- *Alone/ ignore condition.* The alone condition (Mason, Riley, Kyle, Emily, Chloe) involved the participant sitting alone in a room or cubicle after the analyst said, "I'll be back in a few minutes." The ignore condition (all other participants) was identical to the alone condition except that the analyst sat in a corner of the room and did not respond to any participant behavior. An ignore rather than alone condition was used in cases in which the team reported that the participant would probably attempt to leave the room if left alone.
- *Attention condition*. The analyst told the participant that she had some work to do, and then turned away from the participant (but remained within reach). Contingent on problem behavior, the analyst provided the participant with 30 s of attention. A full 30 s of attention was delivered so that the reinforcement intervals for all sessions of all analyses would be equal (e.g., Fisher, Piazza, & Chiang, 1996). If attention was part of the particpant's synthesized consequence in the IISCA, the same type of attention was provided in the standard FA. If attention was not part of the participant's synthesized contingency in the IISCA, the analyst provided generic attention in the form of reprimands and statements of concern.
- *Tangible condition*. A tangible condition was included if access to tangibles was part of the participant's synthesized contingencies in the IISCA. Prior to the start of the condition, participants were given 1 min access to the same tangibles that had been provided in the IISCA. After 1 min, the tangible items were then removed and no other interaction with the analyst occurred. Contingent on problem behavior, the tangible items were returned to the participant for 30 s. Attention was not provided during the 30 s reinforcement interval beyond what was required to approach the participant silently and give him/her the items, to ensure that tangible versus attention contingencies remained as distinct as possible (e.g., Moore, Mueller, Dubard, Roberts, & Sterling-Turner, 2002).

- *Play condition.* During this condition, the same items from the tangible condition were available to the participant and attention was provided on an FT-30 s schedule and whenever the participant initiated an interaction. This attention was provided in the form of comments, compliments, or praise. If an interaction was participant-initiated, the analyst provided the particular type of attention requested or from the interview. If a tangible condition was not included in the FA, the participant was provided with items that teachers reported were preferred. These were provided because the play condition in the standard FA typically includes access to toys (Hanley et al., 2003; Iwata et al., 1982/1994). Problem behavior produced no programmed stimulus change.
- *Escape condition.* The same demands presented in the IISCA were presented during this condition. Contingent on problem behavior, 30 s of escape was provided. The analyst removed the task materials and told the participant he/she did not have to do the task right now. No other attention was provided, and the participant was not allowed to continue interacting with the task materials. Withholding attention and access to the task materials during the escape interval was done to ensure that the escape contingency remained separate from any attention and tangible contingencies.

Precursor FA. The precursor FA was identical to the standard FA described above, except that any precursors that had been reinforced in the IISCA were also reinforced in this analysis, in addition to problem behavior. This means that the only difference between the IISCA and the precursor FA was the synthesis or isolation of consequences. A precursor FA was conducted with any participant for whom precursors were the only response topography observed in the standard FA (i.e., no problem behavior occurred during the standard FA, but precursors did occur).

Conditional probability analysis. Several participants engaged in precursor and problem behavior simultaneously or within a few seconds of each other during the standard FA, making it likely that precursor responses were actually reinforced in both analyses for these participants. The conditional probability of a precursor response contacting reinforcement during the standard FA was calculated by reviewing the data streams and counting the number of precursor responses that were followed by reinforcement within 2 s and dividing by the total number of precursor responses that occurred. This yielded a decimal value ranging from 0 (no precursor responses contacted reinforcement within 2 s) to 1 (all precursor responses contacted reinforcement within 2 s). This analysis was performed for all participants who engaged in precursor responses during the standard FA.

Results

The IISCA was differentiated for 9/9 or 100% of participants, the standard FA was differentiated for 4/9 or 44% of participants, and the precursor FAs for both Mason and Riley were differentiated (see Figures 1, 2, and 3 for individual participant results; see Table 4 for a summary). Mean duration for the IISCA was 28 min (range, 15–70 min; *SD* 16) and mean duration for the standard FA was 90 min (range, 36–200 min; *SD* 49).[3] Thus, when both formats were implemented the way they have been most often described in the literature, the IISCA was differentiated more often than the standard FA and took less time to conduct.

An analysis was considered differentiated if rates of responding in one or more test conditions were elevated relative to rates in the control condition. Regarding precursors and problem behavior, it is possible that both

[3]Analysis duration was calculated by multiplying session duration in minutes by total number of sessions.

occurred during an analysis, that only precursors occurred, or that only problem behavior occurred. Regarding differentiation, we observed four distinct patterns in the standard FA: (a) the standard FA was undifferentiated because no problem behavior occurred; (b) the standard FA was undifferentiated because no problem behavior occurred, but a subsequent precursor FA was differentiated; (c) the standard FA was undifferentiated because problem behavior occurred but was uncontrolled; (d) the standard FA was differentiated.

Figure 1 shows the results for three participants for whom the standard FA was undifferentiated because problem behavior did not occur. Diego (top panel) displayed no responding during the standard FA; Mason and Riley (second and third panels, respectively) displayed precursor responses only. A subsequent replication of the IISCA was differentiated for Diego; a subsequent precursor FA was differentiated for Mason and Riley. Mason's precursor FA was differentiated for escape, which was one of the contingencies included in his IISCA; Riley's precursor FA was differentiated for escape and tangibles, which were the same two contingencies included in his IISCA.

Figure 2 shows the results for two participants (Kyle and Jonah) for whom problem behavior occurred during the standard FA, but was ultimately undifferentiated. For Kyle, problem behavior was not reliably evoked in any particular standard test condition, although precursors persisted unreinforced across all conditions. For Jonah, problem behavior persisted uncontrolled across all standard FA conditions.

Figure 3 shows the results of four participants (Dylan, Emily, Chloe, Jeff) for whom

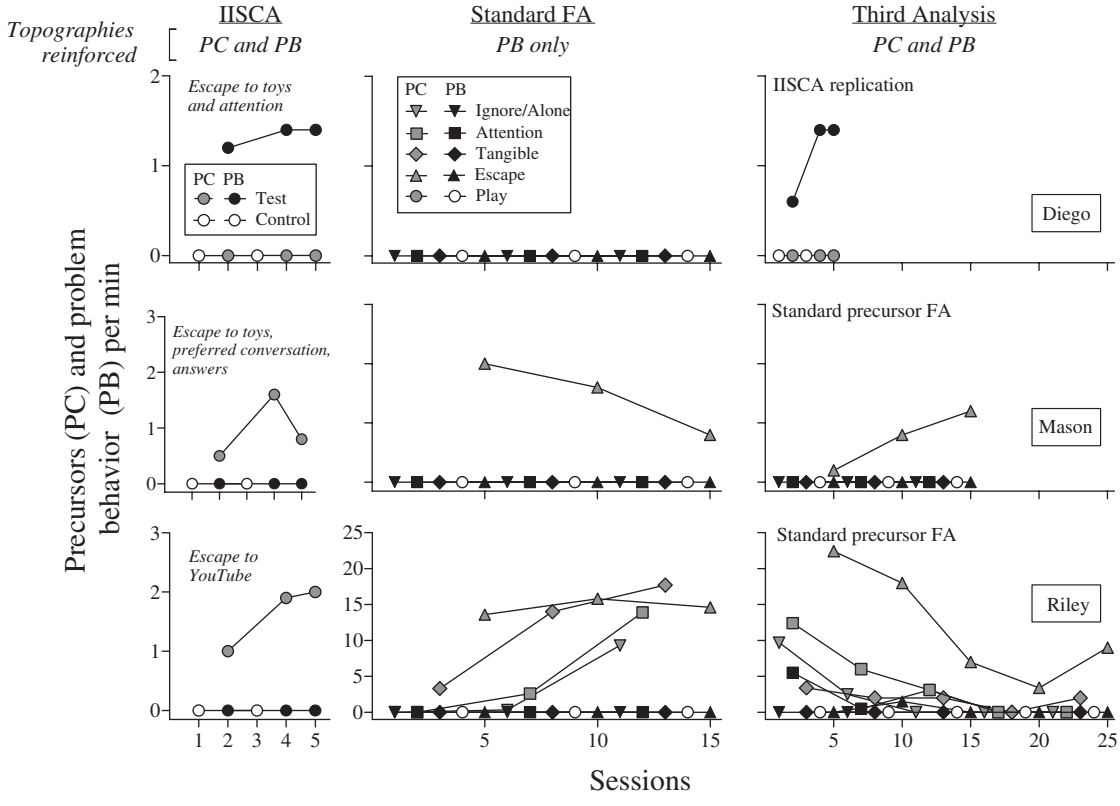

Figure 1. IISCA, standard FA, and follow-up analyses for Diego, Mason, and Riley.

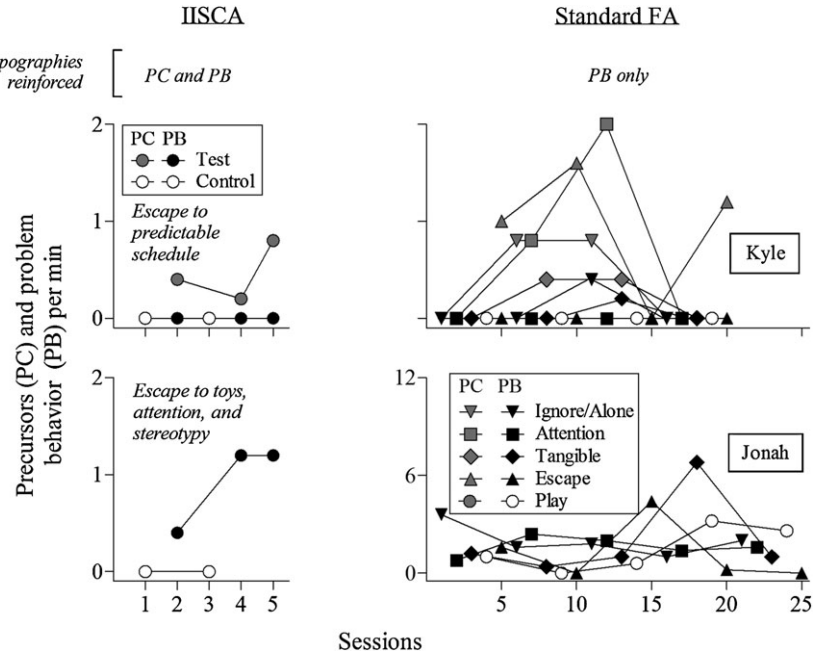

Figure 2. IISCA and standard FA results for Kyle and Jonah. The y-axis denoting *precursors and problem behavior per min* refers to only problem behavior for Jonah, for whom no precursors were identified.

the IISCA and standard FA were both differentiated. Dylan's IISCA was differentiated for escape to toys; his standard FA was differentiated for escape and toys separately. Emily's IISCA was differentiated for escape to music (tangibles) and child-directed interaction (attention); her standard FA was differentiated for escape only. Chloe's IISCA was differentiated for escape to rituals, and her standard FA was differentiated for escape only. It is important to note, however, that we did not include an access to rituals condition in her standard FA because this type of idiosyncratic reinforcer is not typically evaluated in a standard FA. Jeff's IISCA was differentiated for escape to YouTube, and his standard FA was differentiated for attention.

There were two participants (Emily, Dylan) for whom conditional probability values for each session ranged from 0.8 to 1.0 (averages 0.9 and 0.96, respectively), indicating that almost all precursors in the standard FA were reinforced. In addition, there were three participants (Diego, Jonah, Chloe) who did not engage in any precursors during either analysis, and instead engaged in problem behavior exclusively. Thus, there were five total participants for whom identical response topographies were reinforced in both analyses. Of the remaining four participants, conditional probability values for each session ranged from 0.0 to 0.5 for Jeff and Kyle (averages 0.08 and 0.07, respectively), indicating that some precursors were followed by reinforcement during some sessions, but most were not. Conditional probability values were 0 for Mason and Riley, indicating that no precursor responses were ever followed by reinforcement during the standard FA (because no problem behavior occurred and therefore reinforcement was never delivered during the standard FA).

For the four participants for whom both analyses were differentiated, without additional data we could not determine which analysis (if either) had accurately identified the

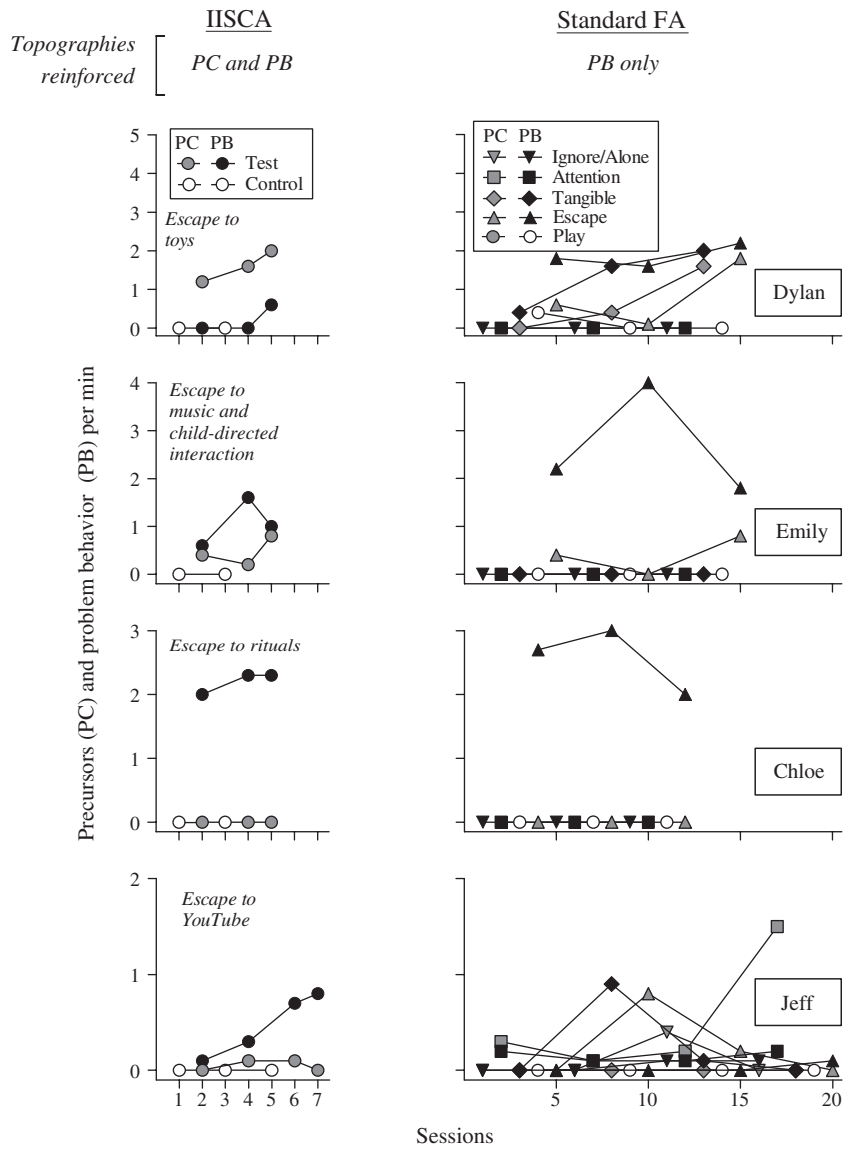

Figure 3. IISCA and standard FA results for Dylan, Emily, Chloe, and Jeff.

reinforcers maintaining problem behavior, because both analyses suggested different functional relations. Although there is precedent for validating the results of descriptive assessments by comparing them to the results of a standard FA (e.g., Camp, Iwata, Hammond, & Bloom, 2009; Hall, 2005; Iwata, DeLeon, & Roscoe, 2013; Lerman & Iwata, 1993; Mace & Lalli, 1991; St Peter et al., 2005, Thompson & Iwata, 2007) and it may seem reasonable to apply this precedent as a means for interpreting IISCA results, the same logic does not hold when comparing two FAs to each other. Both the IISCA and standard FA are experimental; both are capable of demonstrating a functional relation. We therefore conducted a second study to evaluate relative treatment efficacy. In Study 2, we compared function-based

Table 4
Functional Analysis Outcomes

Participant	Function via IISCA	Function via Standard	Function via Standard Analysis of Precursors
Diego	Escape to toys, attention	Undifferentiated	–
Mason	Escape to toys, preferred conversation, answers	Undifferentiated	Escape
Riley	Escape to YouTube	Undifferentiated	Escape, YouTube
Kyle	Escape to predictable schedule	Undifferentiated	–
Jonah	Escape to toys, attention, stereotypy	Undifferentiated	–
Emily	Escape to music, child-directed time	Escape	–
Jeff	Escape to YouTube	Attention	–
Chloe	Escape to rituals	Escape	–
Dylan	Escape to toys	Escape, toys	–

treatments developed from the IISCA and standard FA to determine which treatment was more effective in eliminating problem behavior and establishing an appropriate communication response for these four participants.

STUDY 2: COMPARISON OF FUNCTION-BASED TREATMENTS

We directly compared IISCA-based and standard FA-based functional communication training (FCT) plus extinction (EXT) treatments for problem behavior for the four participants in Study 1 whose standard FAs were differentiated. We evaluated each treatment according to the outcomes of (a) eliminating problem behavior and (b) generating an appropriate functional communication response (FCR).

Method

Participants and setting. Emily, Jeff, Chloe, and Dylan participated in this study. All treatment sessions were conducted by the same analyst who conducted their FAs. The same stimuli that had been included in the relevant FA condition were also used in treatment sessions.

Response definitions, measurement, and IOA. As in Study 1, we recorded all sessions using camcorders or other recording equipment, and data were scored using laptops equipped with the same data collection and analysis program. Response definitions and measurement for problem behavior and precursors were identical to Study 1. In addition, we scored each independent occurrence of the FCR. An occurrence of the FCR was considered independent if the participant began emitting the phrase within 5 s of the evocative event and without any prompts from the analyst. We report problem behavior (including precursors) and independent FCRs as responses per min. Data from each participant's IISCA test condition and their differentiated standard test condition(s) are reported as baseline data against which to judge treatment effects. Procedures for calculating IOA were identical to Study 1. IOA averaged 93% (session range, 87%–97%).

Experimental design. We used a multielement design to compare the effects of FCT + EXT based on each analysis. All sessions were 10 trials or 10 min (whichever came first). Sessions were conducted 2 to 3 days per week, in blocks of two to six sessions (when comparing two FCT conditions) or blocks of three sessions (when comparing three FCT conditions). Sessions were conducted in a random order each day, with the requirement that each condition be experienced the same number of times on a given day. Participants were required to experience a minimum of five sessions in each condition, and the comparison was considered complete when this requirement was met and

rates of problem behavior and independent FCR use appeared stable in at least one condition for at least three consecutive sessions.

Procedures

FCT developed from the IISCA involved teaching an omnibus FCR that produced 30 s of access to the multiple reinforcers for problem behavior identified in the IISCA (Hanley et al., 2014). FCT developed from the standard FA involved teaching an FCR that produced 30 s of access to the isolated reinforcer for problem behavior identified in the standard FA. We signaled the different FCT conditions with color-correlated cards approximately 22 x 28 cm (for participants who communicated vocally) or color-correlated iPad™ buttons approximately 1.5 x 1.5 cm (for participants who communicated with an SGD). All sessions began with the analyst showing the participant the correlated stimulus and describing the contingency in place for that session.

Each trial consisted of the following components: (a) the analyst implemented the evocative event that had produced problem behavior in the FA upon which the treatment was based, (b) the participant emitted the corresponding FCR, and (c) the analyst reinforced the FCR by delivering the reinforcer(s) that had been delivered in that particular FA. For participants who communicated vocally, a model prompt was initially provided to occasion the FCR. For participants who communicated with an SGD, a gesture prompt to push the correct buttons in the correct order was initially provided. The delay to prompts was faded within session: 0 s, 3 s, 5 s. Each instance of the FCR produced 30 s of reinforcement whether it occurred independently or with a prompt. The prompt delay was increased each time the participant completed 4–5 trials at the current delay, until reaching a terminal delay of 5 s. Problem behavior and precursors in both conditions were placed on extinction; the particular reinforcers that were synthesized during IISCA-based FCT could all be withheld at the same time (e.g., both escape extinction and tangible extinction may be implemented simultaneously).[4]

Emily. For both FCT conditions, the EO involved presenting Emily with the demand to brush her hair or unpack her backpack. When this evocative event was presented during IISCA-based FCT sessions, saying "my way please" produced 30 s of escape from these demands, access to preferred music (tangible), and access to child-directed interaction (attention). After 30 s, the music was paused, the analyst stopped engaging in Emily-led interactions, and Emily was instructed to return to work. When the same EO was presented during standard FA-based FCT sessions, saying "take a break please" produced 30 s of escape from demands. No music was provided, the task materials were removed, and the analyst did not provide Emily with any attention. In addition, the analyst stepped back from Emily approximately .6 m to make the delivery of escape more salient.

Jeff. Both of Jeff's FCRs were produced using his SGD, which was an iPad™ equipped with the LAMP Words for Life™ communication app and encased in a Big Grips® foam case for protection. Both FCRs required Jeff to push individual buttons for each word, and both FCRs required an equal number of button presses. Gesture prompts were provided one at a time (i.e., the analyst gestured to "my" and waited for Jeff to push that button, then gestured to "way" and waited for Jeff to push that button). These gesture prompts were faded on

[4]In Emily's case in which attention, tangible, and escape functions were combined, it may seem that escape extinction and attention extinction cannot be implemented simultaneously. However, the specific type of attention being evaluated for Emily was child-directed interaction, which was easily withheld while presenting demands.

a delay as described above. An independent, correct response was scored if Jeff pushed the buttons in the correct order and then pushed the top of the screen to voice the entire phrase, with no more than 5 s pause between button presses and without any prompts from the analyst.

The EO for IISCA-based FCT involved pausing Jeff's YouTube video and instructing him to return to his vocational counting task. Saying "my way" produced 30 s of escape from the vocational task plus access to videos on YouTube. The EO for standard FA-based FCT involved the analyst telling Jeff that she had some work to do, and then turning away from him. Saying "let's talk" produced 30 s of attention from the analyst in the form of talking about any topics Jeff initiated. Jeff communicated primarily with his SGD, but could produce vocal approximations of many words. He initiated topics by producing a word approximation, such as "pi-ta" for "pizza." The analyst would then talk about pizza with Jeff, and Jeff responded by interjecting "yeah" or "okay" as the analyst spoke, or answering simple questions (e.g., saying "mom" when the analyst asked who Jeff was going to eat pizza with later).

Dylan. Dylan experienced three FCT conditions because his standard FA indicated control by two separate reinforcers. We will refer to these latter two conditions as tangible-based FCT and escape-based FCT throughout the rest of the article. The EO for IISCA-based FCT involved telling Dylan he needed to put away his toys and come get his temperature taken. Saying "my way" produced 30 s of escape from the thermometer and access to the preferred toys. The EO for tangible-based FCT involved telling Dylan he had to surrender his toys. The analyst approached him with an outstretched hand to take his toys (with no thermometer present). Saying "toys please" produced 30 s of access to the toys. The EO for escape-based FCT involved telling Dylan he had to get his temperature taken (with no toys present). The analyst approached Dylan with a thermometer to place on his forehead. Saying "not now" produced 30 s of escape from the demand to get his temperature taken.

Chloe. The EO for both conditions involved the analyst attempting to help Chloe put her shoes on. During IISCA-based FCT, saying "my way please" produced 30 s of escape from the analyst's prompts to put the shoes on, as well as access to engaging in ritualistic behavior with the shoes. During standard FA-based FCT, saying "take a break please" produced 30 s of escape only. The analyst moved Chloe's shoes to the side and did not provide access to engaging in ritualistic behavior with the shoes. Attention was not provided during this escape interval, and all requests to engage in ritualistic behavior with the shoes were ignored.

Results

IISCA-based FCT was effective for all four participants (Figures 4 and 5). It was more effective than standard FA-based FCT for Emily and Jeff; it was equally effective as standard FA-based FCT for Chloe and Dylan. For Emily, problem behavior was eliminated during IISCA-based FCT after one session. The FCR *my way please* began occurring independently during the second session, and was acquired by the third session. For Jeff, no problem behavior occurred during any IISCA-based FCT session; the FCR began occurring independently during the first session and was acquired by the fifth session. By contrast, problem behavior persisted during standard FA-based FCT for both of these participants, and neither participant acquired the standard FA-based FCR. It should be noted that both Emily and Jeff did engage in many prompted instances of the standard FA-based FCR, and thus they contacted the reinforcement contingency many times each

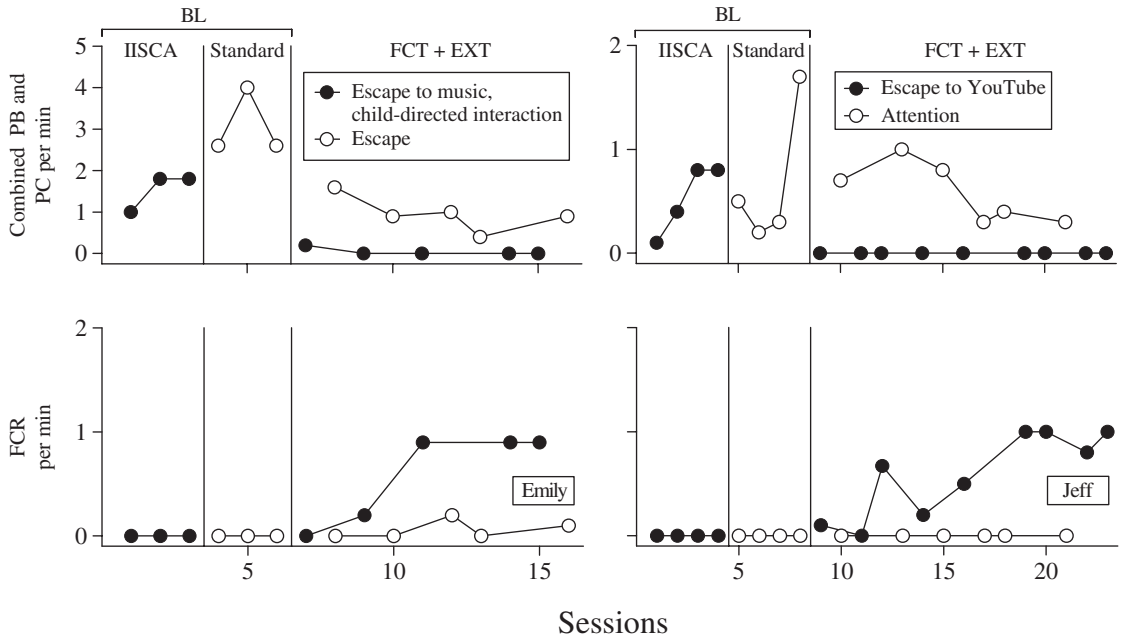

Figure 4. Rate of combined problem behavior and precursors and independent FCRs during IISCA-based FCT and standard FA-based FCT treatment for Emily (left panels) and Jeff (right panels).

session. However, independent use of the standard FA-based FCR was never established. In both conditions, any FCRs emitted were relevant to the condition (i.e., the IISCA-based FCR never occurred during standard FA-based sessions, and vice versa).

Both treatments were equally effective in eliminating problem behavior and establishing FCRs for Dylan and Chloe (see Figure 5). In Dylan's case, no problem behavior occurred during IISCA-based FCT or tangible-based FCT; minimal problem behavior occurred during one session of escape-based FCT. In Chloe's case, problem behavior (grabbing the analyst) initially occurred during both FCT conditions, but was reduced to zero by the eighth session in each condition. All FCRs were easily acquired by the second session for both participants and occurred at similar rates across conditions. In addition, both Dylan and Chloe exclusively used the FCR relevant to each condition.

DISCUSSION

The results of our Study 1 revealed that when implemented as they have been most often described in the literature, the IISCA was differentiated more often than the standard FA (100% versus 44% of applications) and was more efficient. Our results regarding the speed and efficacy of the IISCA in demonstrating a functional relation between problem behavior and environmental events are similar to those reported by others who have evaluated the IISCA (Ghaemmaghami et al., 2015, 2016; Hanley et al., 2014; Jessel et al., 2016; Santiago et al., 2016). We compared function-based treatments in Study 2 and found that IISCA-based treatment was effective in all four cases and standard FA-based treatment was similarly effective in two cases. Taken together, the results from Study 1 and Study 2 suggest that the IISCA can be an effective format for assessing and treating socially mediated problem behavior.

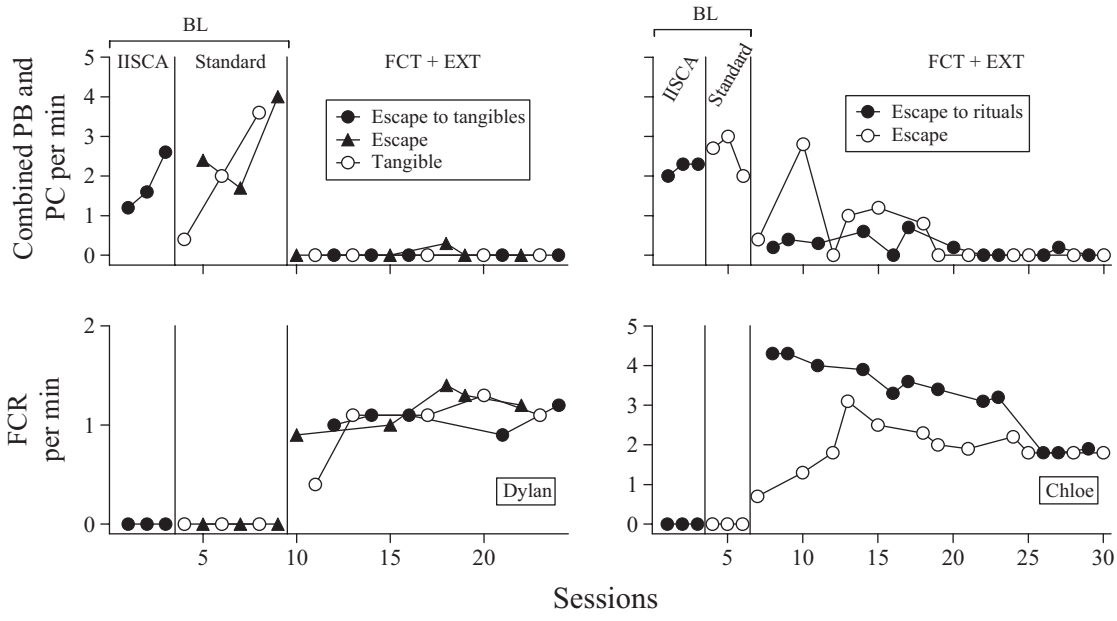

Figure 5. Rates of combined problem behavior and precursors and independent FCRs during IISCA-based FCT and standard FA-based FCT treatment for Dylan (left panels) and Chloe (right panels).

Regarding Study 1, there are several possible reasons the IISCA was differentiated more often than the standard FA. The first and most obvious may be that precursors were reinforced in the IISCA and not in the standard FA. There were five participants for whom the standard FA was undifferentiated; we examined the possibility for each of them. For Diego and Jonah, precursors did not occur or were not reported. Thus, the lack of differentiation in their standard FAs was not related to the exclusion of precursors. For Mason and Riley, the exclusion of precursors was directly responsible for the lack of differentiation in their standard FAs. We conducted precursor FAs for both of these participants, allowing us to evaluate response rates when the same contingencies of the standard FA were applied to precursors observed in the IISCA, and saw differentiated rates when precursors were reinforced in the standard FA.

A second possible reason that the IISCA was differentiated more often than the standard FA may be that problem behavior for some participants was maintained by interactions between contingencies. For example, Diego's outcomes show that his problem behavior was evoked by a synthesis of EOs and maintained by a synthesis of reinforcers, rather than by any one EO or consequence in isolation. The fact that problem behavior for Jonah was controlled and differentiated in the IISCA but not in the standard FA also suggests the potential presence of important interactions. Jonah's IISCA contained an arrangement of variables capable of reliably evoking problem behavior as well as reliably suppressing it; by contrast, the arrangement of variables in the standard FA did not produce control. There are a number of other reported instances in which a synthesis of contingencies reliably controlled problem behavior when isolated contingencies failed to do so (e.g., Adelinis & Hagopian, 1999; Bowman et al., 1997; Fisher et al., 1998; Ghaemmaghami et al., 2015; Hanley et al., 2014; Mann & Mueller, 2009; Mueller et al., 2005;

Sarno et al., 2011). The results for Diego and Jonah in Study 1 highlight the importance of considering interactions in addition to main effects when analyzing problem behavior. One advantage afforded by the IISCA may be its ability to evoke problem behavior that is sensitive only to interactions.

The presence of interactions between contingencies may have also contributed to the fact that IISCA-based FCT was more effective than standard FA-based FCT for Emily and Jeff in Study 2. It is possible that interactions were present and went undetected even though their standard FAs were differentiated (for other examples, see Mann & Mueller, 2009; Payne et al., 2014). For example, Emily's standard FA indicated a clear escape function, and no problem behavior or precursors occurred in any other condition. However, despite these clear results, a treatment based on escape as the maintaining consequence did not eliminate problem behavior. The addition of music and child-directed interaction during the reinforcement interval was necessary for treatment effects to be observed with Emily (as demonstrated in the IISCA-based treatment). The fact that no problem behavior occurred in the attention or tangible condition of her standard FA indicates that these EOs were not sufficient to evoke problem behavior in and of themselves, but it does not rule out the possibility that these events interact with other reinforcers to maintain problem behavior. Emily's treatment data make it clear that music and child-directed interaction *were* in fact relevant to her problem behavior, despite the fact that they were not detected by the standard FA.

Our results from Study 1 are similar to those of Fisher et al. (2016) in that both analyses detected similar though not identical reinforcers for most participants. However, our interpretation of those results differs significantly. Fisher et al. provided an interpretation of IISCA and standard FA outcomes based on comparing the two analyses to determine the extent to which the IISCA detected the same reinforcers as the standard FA. In other words, these authors used the standard FA as an answer key of sorts against which to evaluate the validity of the IISCA. This interpretation assumes that the standard FA is a truth-bearing criterion that provides the correct answer regarding the reinforcers that maintain problem behavior, and analyses that provide different information must therefore be incorrect. However, rather than assume the veracity of one analysis based on the fact that it has been applied more often, our results from Study 2 suggest that a more pragmatic strategy is to compare the relative efficacy of treatments designed from sets of differentiated analyses. The IISCA-based treatment eliminated problem behavior in all cases and established an appropriate alternative response in all cases. These factors are especially important given that a primary purpose of an FA is to develop an effective function-based treatment for problem behavior. We think this pragmatic approach is preferable because it judges the value of an analysis by the extent to which its corresponding treatment produces meaningful outcomes. We caution against dismissing the utility of the IISCA based on the conclusion that its results do not match those of the standard FA, particularly given that the data from Study 2 indicate that the IISCA produced effective treatment more often than the standard FA.

The tactic of examining treatment data to affirm (or reject) FA conclusions has been successfully used by several other authors. For instance, Smith, Iwata, Vollmer, and Zarcone (1993) noted that problem behavior occurring in multiple test conditions could reflect maintenance by multiple reinforcers or a failure to isolate the necessary variables. These authors sought to affirm the functions detected in the analysis by implementing treatments based on each function and found that problem behavior was in fact multiply maintained for two of

three participants. Payne et al., (2014) reported two cases in which treatment based on the results of an FA was not effective in eliminating problem behavior. Subsequent analyses determined that some interactions between reinforcers had not been detected by the FA (e.g., problem behavior was maintained by escape to attention), and treatment modifications based on these combined reinforcers were found to be effective. In a third example, Ghaemmaghami et al. (2015) conducted an IISCA that synthesized the reinforcers of escape, attention, and tangible items, and found that problem behavior was eliminated during treatment when and only when mands for *all* reinforcers were acquired, affirming that the reinforcers included in the IISCA were all relevant parts of the contingency maintaining problem behavior.

There are several additional interpretations offered by Fisher et al. (2016) that are important to discuss: (a) maintenance by interactive effects is the underlying assumption of the IISCA; (b) the IISCA is therefore validated only when response patterns presumably indicative of interactive effects are observed between the IISCA and standard FA; (c) including extra stimuli that do not function as reinforcers in the IISCA can be problematic because it may lead to an unnecessarily cumbersome treatment. There are a number of conceptual and practical problems with these premises and the conclusions that follow from them.

The IISCA does not assume maintenance by interactive effects. Hanley et al. (2014) did not describe this as the rationale for the assessment and treatment model, nor did other authors who have reported using IISCAs (e.g., Ghaemmaghami et al., 2015, 2016; Jessel et al., 2016; Santiago et al., 2016). The description of the IISCA as assuming interactive effects is unique to Fisher et al. (2016). In their discussion, Hanley et al. note that a synthesis of contingencies allowed problem behavior to be quickly evaluated in the typical contexts in which it occurred, that the assessment produced a useful baseline against which to evaluate treatment effects, and that "support for the synthesized contingency analyses…. comes from the meaningful outcomes produced for all three participants" (p. 33). In other words, the primary reason these authors offered for synthesizing contingencies is that emulating ecologically relevant scenarios can assist in producing large, generalizable, and socially validated effects.

Hanley et al. (2014) do point out the importance of the synthesized contingency for participant Gail in that her problem behavior occurred when and only when contingencies were synthesized, and they suggest that reinforcing effects of contingencies can be missed when evaluated in isolation. The independent effects of each reinforcer were not evaluated for participants Bob and Dale in Hanley et al., but their treatments were highly effective and socially validated anyway. We found that a synthesis of reinforcers was not necessary to produce effective treatment for two of four participants (Dylan and Chloe), yet their IISCAs were differentiated and were completed in fewer sessions than the standard FA. Additionally, IISCA-based treatment was effective even with the inclusion of possibly irrelevant contingencies, which more closely mimicked the situations reported by caregivers as problematic. Thus, an important point regarding the utility of the IISCA is that it has been shown to produce effective treatment *regardless of whether* problem behavior is maintained by interactive effects (Gail in Hanley et al.; Emily in the current study), independent effects (Dylan, Chloe in the current study), or whether the independent effects are unknown (Bob, Dale in Hanley et al.). More importantly, our results for Emily and Jeff suggest that the standard FA can sometimes miss potential interactions and therefore produce treatments that are not effective, even when the FA is differentiated. This outcome seems more

problematic than a treatment including potentially incidental stimuli that do not function as reinforcers.

Regarding the concern that including incidental stimuli in an IISCA may produce a more cumbersome treatment, this did not appear to be the case for Dylan or Chloe in Study 2. Dylan's escape-based FCT treatment was actually *more* cumbersome to implement because we had to clear the session room of all toys to ensure that he could not wander around the room and access preferred toys during his escape interval. Typical school, clinic, and home environments are not devoid of toys or other tangible items, and it is not likely that parents or practitioners would specifically prohibit access to toys during treatment based on an escape function. Thus, whether or not tangible items are *relevant* to the maintenance of problem behavior, it may actually be less cumbersome and more practical to provide escape to tangibles (instead of escape to nothing) during treatments for escape-maintained problem behavior. In addition, although Dylan's tangible-based FCT condition was effective in eliminating problem behavior, it did not address the need for caregivers to be able to take his temperature (a primary concern of his caregivers). A second treatment would be necessary to establish compliance with this and other related demands, which would necessitate that caregivers be trained in two different treatments. This seems more cumbersome than a synthesized treatment shown to be equally effective.

It is interesting to note that the percentage of differentiation we obtained with the standard FA (44%) is similar to that reported by Hagopian et al. (2013) in which only 47% of standard FAs were differentiated on the first attempt. There are a considerable number of ways in which the standard FA may be modified when differentiated results are not initially obtained (such as including precursors in the contingency class), and one limitation of the present study is that continued attempts to modify and refine the standard FA may have produced differentiation and effective treatment for more participants (as was evident in Hagopian et al.). However, it is important to consider that the process of modifying and re-running the analysis is time consuming and may require a level of expertise that is not easily accessible outside of specialized hospital or clinic settings. As an example, the BCBAs who worked with our participants as part of their school program had an average caseload of 10 students to oversee, which amounts to about 3 hours per student per week given a 30-hour school week. It is possible that conducting three iterations of a standard FA could take 3 or more weeks when operating under those time constraints. Instead of conducting multiple iterations of an analysis to obtain differentiation, an alternative course could be to design individualized test-control analyses from open-ended interviews at the start (Hanley, 2012; Hanley et al., 2014). Our results suggest that synthesizing multiple variables suspected of influencing problem behavior is likely to produce an efficient analysis that is differentiated on the first attempt (Study 1) and a treatment that is also effective (Study 2).

Although we found the IISCA to be differentiated and to produce effective treatment more often than the standard FA, we do not mean to suggest that it can or should now supplant the standard FA under all conditions. The development of the standard FA was the catalyst for a critical paradigm shift to function-based treatment for problem behavior; as a research platform, it allows behavior analysts to continue evaluating isolated components of analyses and treatments to determine their value. In their discussion, Hanley et al. (2014) emphasized the bidirectional nature of studies that synthesize multiple assessment or treatment components and studies that evaluate these variables in isolation. In particular, these authors noted that empirical evaluations of synthesized treatments can suggest additional

independent variables to be more closely examined in isolation, and these types of highly analytic examinations can in turn yield isolated variables that comprise the constituent parts of synthesized treatment packages with long-term, generalized, meaningful outcomes. The present studies occasion a number of questions along both such lines of research.

For instance, it may be important to isolate the effects of synthesized response topographies from the effects of synthesized consequences. These effects could be separated from each other by conducting IISCAs and standard FAs in which identical topographies are reinforced in each analysis (as we did for five of our nine participants). It may also be important to isolate the effects of synthesized versus isolated EOs. If multiple EOs are presented in a test condition but only one reinforcer is provided (e.g., escape), it is difficult to determine whether problem behavior was evoked by the EO for that particular reinforcer, by the EO for another reinforcer, or by some combination of EOs. Future research could address this question by comparing conditions in which multiple EOs are arranged and a single reinforcer is provided (e.g., Call & Lomas Mevers, 2014; Call, Wacker, Ringdahl, & Boelter, 2005), multiple EOs are arranged and all reinforcers are provided (e.g., an IISCA), or an isolated EO is arranged by providing continuous access to all reinforcers but one (e.g., Gail's isolated analyses in Hanley et al., 2014).

An important area of research related to the continued evaluation of synthesized analyses and treatments is to determine the impact of including incidental stimuli in synthesized contingencies during treatment (i.e., including stimuli whose independent effects were not demonstrated). Will doing so impede treatment or enhance it? The inclusion of incidental stimuli did not seem problematic for Dylan and Chloe's treatments. However, we did not evaluate their treatments over longer periods of time, in additional contexts, or under thinner schedules of reinforcement. Our conclusions regarding the acceptability of including incidental stimuli in synthesized treatments must therefore be tempered by the short duration over which treatment was applied. Extending the comparison beyond the very first stages of intervention is a critical next step.

Finally, the continued evaluation of the generality of the IISCA will be important, as there are currently only a handful of published studies demonstrating its use, and even fewer studies comparing it and its derived treatments to other FA formats and their derived treatments. In particular, studies focusing on the long-term efficacy, generality, and social acceptability of treatments relying on isolated versus synthesized contingencies will be most important in determining the relative benefits and costs of focusing on these different types of precision when analyzing and treating problem behavior. Considering that many practitioners report rarely conducting FAs (Ellingson, Miltenberger, & Long, 1999; Oliver, Pratt, & Normand, 2015; Roscoe, Phillips, Kelly, Farber, & Dube, 2015) and given that research on the IISCA is only beginning, it will be important to continue to evaluate the extent to which the IISCA or any other FA format is efficient, effective, *and* readily adopted by practitioners in the coming years.

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