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Interview informed functional analyses : a comparison of synthesized and isolated variables

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INTERVIEW INFORMED FUNCTIONAL ANALYSES: A COMPARISON OF SYNTHESIZED AND ISOLATED VARIABLES

By

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Abstract

Hanley, Jin, Vanselow, and Hanratty (2014) described a functional analysis format that synthesized several variables based on information from open-ended interviews. This analysis provided an effective baseline from which to develop socially validated treatments, but the synthesis precluded a precise understanding of individual contingencies influencing problem behavior. In Study 1, we compared interview-informed synthesized contingency analyses (IISCA) and standard functional analyses (Iwata et al., 1982/1994) for nine children with autism. Response topographies (precursors and problem behavior) and consequences were synthesized in the IISCA; neither was synthesized in the standard analysis. The IISCA was differentiated for all nine participants. The standard analysis was differentiated for four participants; this number increased to six when we repeated the analysis and included precursors. We then compared treatments developed from the sets of differentiated analyses. IISCA-based treatments were effective in all applications; standard-based treatments were effective in half of the applications.

Keywords: autism, functional analysis, functional communication training, IISCA, problem behavior, synthesized analysis

Interview-Informed Functional Analyses:
A Comparison of Synthesized and Isolated Variables

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). 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) 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. This information 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).

In their seminal article, Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) described a functional analysis that included test conditions for each of the most commonly suspected operant classes of problem behavior (automatic reinforcement, socially mediated positive reinforcement, socially mediated negative reinforcement). In a recent review of FA literature, Jessel, Hanley, and Ghaemmaghami (under review) describe several core features of this analysis format that have been widely adopted by other researchers: the use of multiple test conditions; the evaluation of isolated reinforcers in each test condition; the use of a generic toy-play control; the use of generic consequences in test conditions[1]. These authors noted that there is an increasing trend in published analyses that include these four components, and that we may

[1] By *generic consequences*, we mean consequences that are uniform across participants and are not individualized or idiosyncratic. For example, an attention condition typically includes generic reprimands and statements of concern such as, “don’t do that; you’ll hurt yourself.”

therefore refer to an analysis with these components as a *standard* functional analysis.

A number of modifications to the standard analysis have been investigated over the last several decades, most of which are aimed at producing results more quickly or overcoming obstacles to implementation (i.e., making the analysis more practical and accessible to practitioners in a variety of settings). Modifications that address these issues of efficiency and practicality have been described together a number of times (e.g., Hanley, 2012; Iwata & Dozier, 2008; Jessel et al., under review), so we shall not extensively review them here. However, we will briefly note that these modifications generally involve changing the duration of sessions (Wallace & Iwata, 1999), conducting a brief analysis with only one session per condition (Derby, et al., 1992; Northup, et al., 1991), using latency rather than response rate as a measure (Thomason-Sassi, Iwata, Neidert, & Roscoe, 2011), including precursors in the contingency class (Borrero & Borrero, 2008; Langdon, Carr, & Owen-DeSchryver, 2008; Smith & Churchill, 2002), or conducting trial-based analyses (Bloom, Iwata, Fritz, Roscoe, & Carreau, 2011; Sigafoos & Saggers, 1995). Though they depart from one or more aspects of the procedures described by Iwata et al., these modifications still retain the four core components of the standard analysis noted above.

In some cases, however, it may be necessary to deviate from these core components, particularly when an analysis does not produce conclusive results. Modifications to antecedents, contingency class, consequences, or design may be required when the first iteration of a standard analysis is undifferentiated. For example, Hagopian, Rooker, Jessel, and DeLeon (2013) reported that 53% of standard analyses (94 of 176) were undifferentiated on the first attempt; these data suggest that the standard analysis may need to be modified and repeated more than half the time. There is not one specific process for modifying FA conditions when data are undifferentiated,

but there are a considerable number of these different modifications reported in the FA literature. Despite the strong empirical support for functional analysis and the technology available for modifying the analysis, surveys regarding practitioner use of functional analysis indicate that the majority of respondents do not conduct them with their clients (Ellingson, Miltenberger, & Long, 1999; Oliver, Pratt, & Normand, 2015; Roscoe, Phillips, Kelly, Farber, & Dube, 2015). According to survey respondents, some reasons why functional analysis is not used more often include lack of space, trained staff, and time (Roscoe et al., 2015); some practitioners also report that they believe functional analysis is more difficult and less effective than other assessment methods (Ellingson et al., 1999). Given that a standard analysis may frequently require modification and that practitioners report not using functional analysis because they find it difficult, ineffective, and/or time-consuming, it is important that we continue to investigate different FA modifications that may address some of these concerns.

One possible modification is to combine idiosyncratic reinforcers in a single test condition. For example, Bowman, Fisher, Thompson, and Piazza (1997) reported an analysis 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 analysis 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 functional analyses. These authors identified 42 studies published between 2001 and 2010 in which the standard analysis 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. (2013) are important because they demonstrate the value of considering individualized variables in FAs and the successful modification of the standard analysis with the inclusion of idiosyncratic variables.

Thus, the FA literature is populated with modifications to the standard analysis that retain its core components while increasing efficiency, or modify some core components to achieve differentiation with combined or idiosyncratic variables. Hanley, Jin, Vanselow, and Hanratty (2014) reported a functional analysis format that included modifications in both of these categories--modifications to increase efficiency as well as modifications that deviated from the core components of a standard analysis by including idiosyncratic and combined reinforcers. These authors used an open-ended interview to identify reinforcers suspected of influencing problem behavior, and these reinforcers were synthesized in a single test condition that emulated the naturally occurring contexts 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, Jin, & Vanselow, 2015; Jessel, Hanley, & Ghaemmaghami, in press).

The IISCA shares some similarities with a pair-wise analysis (Hanley, Iwata, &

Thompson, 2001; Iwata, Duncan, Zarcone, Lerman, & Shore, 1994) in that a single test and control condition are alternated, but with the two fundamental differences of synthesized versus isolated contingencies and a matched versus generic control condition. The IISCA also packages together other modifications that have been reported separately by a number of authors: a single test condition rather than multiple test conditions (Adelinis & Hagopian, 1999; Bowman et al., 1997; Fisher et al., 1998); combined rather than isolated reinforcers (Mann & Mueller, 2009; Mueller, Sterling-Turner, & Moore, 2005); idiosyncratic rather than generic variables (see Schlichenmeyer et al., 2013, for a review); shorter session duration (Wallace & Iwata, 1999); reinforcing co-occurring topographies of problem behavior (Lalli, Mace, Wohn, & Livezey, 1995; Magee & Ellis, 2000; Richman, Wacker, Asmus, Casey, & Andelman, 1999); reinforcing precursors to problem behavior (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 modifications is novel, however, and allows for rapidly and strongly differentiated analyses (Jessel et al., in press) that leads to highly effective treatment outcomes (Ghaemmaghammi, Hanley, & Jessel, in press; Hanley et al., 2014, Santiago, Hanley, Moore, & Jin, 2015). Nevertheless, because multiple antecedents and consequences for multiple topographies of behavior are synthesized in the IISCA, the relevance of each variable in any demonstrated functional relation is unclear.

The IISCA involves a synthesis of each component of the three term contingency: antecedents (EOs), behaviors (response topographies), and consequences. By contrast, the standard analysis involves isolation of response topographies and consequences, and usually a synthesis of antecedents (though it is not typically described this way). For example, during the attention condition of a standard analysis, attention is withheld until problem behavior occurs.

However, highly preferred tangible items are also withheld (and never delivered during this condition). EOs for attention and tangible items are therefore present in the attention condition. This same EO synthesis is present in most tangible and alone conditions of a standard analysis. Similarly, the escape condition contains EOs for escape as well as for tangible items and attention. When problem behavior occurs in a particular test condition of the standard analysis, it may be evoked by any one of several EOs or some combination thereof. The IISCA and standard analysis therefore both typically include a synthesis of EOs, whereas the last two components of the three-term contingency (behaviors and consequences) are synthesized exclusively in the IISCA.

Response topographies are synthesized in the IISCA 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 test condition. The inclusion of precursors has been reported by other authors who have conducted an IISCA (see Jessel et al., in press), and can be considered a characteristic feature of that format. Reported or observed precursors have been shown to be members of the same operant class as problem behavior (Borrero & Borrero, 2008; Herscovitch, Roscoe, Libby, Bourret, & Ahearn, 2009; Langdon et al., 2008; Smith & Churchill, 2002), as have co-occurring topographies of problem behavior (Lalli, Mace, Wohn, & Livezey, 1995; Magee & Ellis, 2000; Richman, Wacker, Asmus, Casey, & Andelman, 1999).

Consequences are synthesized in the IISCA based on reports of outcomes that tend to occur together following problem behavior. For example, with 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. By contrast, a single type of problem behavior (e.g. aggression *or* SIB) is usually reinforced with a single consequence in each test condition of a standard analysis (Beavers et al., 2013; Hanley & McCord, 2003; Iwata & Dozier, 2008; Iwata et al., 1982/1994; Jessel et al., under review). A standard analysis may include precursors, but this is considered a modification rather than a characteristic feature of the analysis (Iwata & Dozier, 2008).

By synthesizing or isolating different components, the IISCA and standard analysis both offer different types of precision. By isolating consequences in each test condition, the standard analysis offers precision in identifying the individual impact of each reinforcer suspected of influencing problem behavior. By combining variables that are reported to occur together, the IISCA offers precision in emulating the natural contexts in which problem behavior typically occurs. At present, we do not know the relative contributions 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 reinforcer suspected of maintaining problem behavior, 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 and standard analyses to determine whether both analyses are differentiated, whether they suggest different functions of problem behavior, and whether subsequent treatments based on both analyses are effective.

Fisher, Greer, Romani, Zangrillo, and Owen (in press) report data for five participants with whom they conducted an IISCA and standard analysis. Each participant experienced what the authors termed a *synthesized analysis* (IISCA) and a *traditional FA* (standard analysis), both

conducted following an open-ended interview and a brief observation. EOs were synthesized in both analyses; consequences were synthesized in the IISCA only. 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 analysis 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 tangibles; their standard analyses were both differentiated for tangibles. The data reported by Fisher et al. (in press) indicate that the IISCA and standard analysis 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 analysis are needed for several reasons. First, Fisher et al. (in press) represents the only comparative evaluation of the IISCA and standard analysis 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 standard analysis. Because the purpose of a functional analysis is to obtain information that can be used to develop an effective treatment, it is particularly important to know whether these two analysis formats yield treatments that are equally effective. In Study 1, we conducted IISCAs and standard functional analyses with nine participants to determine the relative probability of differentiated outcomes; in Study 2, we compared treatments developed from both analyses (when both were differentiated) to determine relative treatment efficacy and – by extension – the relative merit of each analysis format.

Study 1: Comparison of IISCA and Standard Functional Analysis

Our nine participants each experienced the IISCA first and then the standard analysis.

This sequence was arranged because exposure to some of the contingencies in the first analysis makes it more likely that the second analysis may be differentiated; we chose to give this potential advantage to the standard analysis. In addition, when evaluating new formats of functional analysis, there is precedent for conducting the new format first and then comparing results to those from the standard format (e.g. Bloom, Iwata, Fritz, Roscoe, & Carreau, 2011; Langdon, Carr, & Owen-DeSchryver, 2008; Thomason-Sassi, Iwata, Neidert, & Roscoe, 2011). We conducted at least as many test sessions of the standard analysis as had been conducted in the IISCA. Our purpose was not to continue modifying conditions and conducting numerous iterations until both analyses were differentiated, but to determine which analysis produced differentiation given a similar number of test sessions.

If problem behavior occurred in both analyses (whether differentiated or not), the child's participation in Study 1 was complete. If no problem behavior occurred in a particular analysis, we conducted a third analysis to obtain more information. For children who did not engage in any problem behavior *or* precursors during the standard analysis, our third analysis was a replication of the IISCA to verify that the functional relation it had initially detected was still operating. For children who did not engage in any problem behavior during the standard analysis but who *did* engage in precursors, our third analysis was a standard precursor analysis in which both precursors and problem behavior were reinforced. This allowed us to further evaluate the role of synthesis by combining response topographies across analyses and comparing synthesized versus isolated consequences only. Study 1 may therefore be characterized as a comparison of the IISCA and standard analysis formats as typically described in the literature, as well as a comparison of specific components of those formats.

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 functional analysis 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. These data represent the first nine children referred to the study. 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 time-out; four participants were unable to attend school field trips or outings because of the chance that problem behavior may occur in the community; one participant was often an hour late to school because of problem behavior during his morning routine.

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 years old 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, bolting, 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 session 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, or electronics). Classrooms were approximately 6 by 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 Inter-observer Agreement (IOA). Sessions were 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. We report problem behavior 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 in a chair; bolting was defined as running more than 2 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 functional 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 minutes or longer without problem behavior, and that problem behavior was more likely to occur as his work task approached 10 minutes in duration or when he was required to 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 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 analysis for each participant isolated variables that were first 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 emulated the combination of establishing operations and consequences reported by team members. By contrast, the standard analysis parsed apart events reported to occur together.

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 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 evocative situations and potentially 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 the analysis.

IISCA. Each IISCA included a control condition and a single test condition. The control

condition for each participant included continuous access to the multiple putative reinforcers arranged in the test condition, thereby eliminating any establishing operation for these reinforcers in the control condition. Problem behavior in the control condition produced no stimulus change. It is important to note that putative reinforcers must have been reported in the interview as sometimes following problem behavior in order to be included in the analysis. In other words, we did not "throw the kitchen sink" in the analysis so to speak; 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 did not otherwise attend to him/her and never provided any unsolicited attention. The test condition contained the multiple establishing operations reported to evoke problem behavior, and the occurrence of problem behavior or precursors produced 30 s of access to the multiple putative reinforcers.[2] With one exception, the sequence of conditions for all participants was control, test, control, test, test.[3] 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. Individual IISCAs are described below and summarized in Table 3.

Diego. Diego's control condition involved the analyst reading aloud to him from preferred books, providing access to preferred toys, and the absence of any demands. During the

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

[3] 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.

test condition, the analyst stopped reading to Diego, removed his toys, and instructed him to complete a handwriting worksheet. Handwriting was selected as the demand because it was one of several demands frequently reported to evoke problem behavior and because Diego's occupational therapist expressed concern that he was not making progress with handwriting. Contingent on precursor or target behavior, the handwriting demand was removed, Diego was allowed to play with his toys, and the analyst read aloud to him again. We describe Diego's contingency as escape to toys and attention.

Mason. Mason's control condition included free access to a toy car and laminated pieces of colored construction paper, responses to Mason's vocal initiations (most of which consisted of "inside jokes" like asking the analyst what a copy machine says), and the absence of any demands. During the test condition, the analyst removed Mason's toys, presented a reading task, and did not respond to any of his vocal initiations. This particular demand and the withholding of attention were included because staff reported that problem behavior tended to occur when Mason's bids for attention were not returned and he was instructed to do something else instead. Every 5 s, the analyst silently pointed to the word for Mason to sound out, and did not provide any other attention or instruction. Contingent on precursor or target behavior, the analyst removed the reading task, provided Mason with his toy car and laminated papers, and responded to all of his vocal initiations. This included consoling him and telling him the correct answer to the reading task (e.g., "It's okay; I know it's a hard word. That word is *hamburger*.") We describe Mason's contingency as escape to toys, preferred conversation, and answers.

Riley. Riley was referred to participate in the study because he engaged in problem behavior when instructed to take medicine, and his doctor had prescribed a daily pill for him to take at home. Riley also had free access to DVDs, TV, or YouTube at almost all times at home,

including while getting dressed, eating, and falling asleep; problem behavior was reported to occur when Riley was asked to do something that interfered with this activity (such as leaving the computer and coming to the kitchen to take medicine). Riley's control condition included access to YouTube and the absence of any demands to take medicine. During the test condition, the analyst paused Riley's YouTube video and told him it was time to practice taking "medicine" (small sugar dots that looked like pills). Contingent on precursor or target behavior, the bowl with the sugar dots was removed and access to YouTube was provided again. We describe Riley's contingency as escape to YouTube.

Kyle. During Kyle's control condition, the analyst presented a written schedule of preferred activities to complete such as playing with toys and watching YouTube. The schedule ended with a preferred snack. Kyle completed the activities on his schedule without any interruptions or changes to the schedule. In the test condition, the analyst announced a surprise change to Kyle's schedule by erasing the snack at the end of the schedule and presenting a non-preferred money-counting task that was not on the schedule (e.g., "I'm sorry Kyle; there's been a change in your schedule. We have to practice counting money now and we're not going to be able to have snack later."). Contingent on precursor or target behavior, the analyst stopped the money-counting task, allowed Kyle to return to his original schedule of preferred activities, and wrote the snack back on the end of the schedule. The snack itself was not delivered at all during the analysis; problem behavior produced a change to the written schedule only.[4] The adding and erasing of a snack item on the schedule was included because staff reported that Kyle typically plans out meals on his calendar several weeks in advance, and schedule changes tend to evoke problem behavior when the change involves food. We describe Kyle's contingency as escape to a preferred, predictable schedule.

[4] Kyle was allowed to eat the snack after the analysis was complete.

Jonah. Jonah's control condition consisted of free access to his "fun space" which was a small empty room approximately 1.5 x 1.5 m in which he could run in circles and jump, hold and tap small plastic toys, and had undivided attention from the analyst. The analyst stood in the room with Jonah, maintaining eye contact and responding to any of his initiations (such as hugging him when he approached with his arms outstretched). A large pillow was present for Jonah to jump on, and no demands were presented. During the test condition, Jonah was directed to complete a puzzle at his desk right outside the space. The analyst blocked any attempts to engage in motor stereotypy and provided minimal attention while Jonah worked on the puzzle. Contingent on target behavior[5], the analyst removed the puzzle, allowed Jonah to return to his "fun space" and engage in motor stereotypy, and provided undivided attention. We describe Jonah's contingency as escape to toys, attention, and stereotypy.

Emily. In Emily's control condition, preferred music was playing, the analyst responded to all of Emily's requests to repeat certain phrases, did not provide attention unless Emily initiated first, and no demands were presented. In the test condition, the analyst turned off Emily's music, no longer responded to Emily's initiations, and presented demands to brush her hair or unpack a backpack. If Emily made a mistake, the analyst named the mistake and physically prompted a correct response (e.g., "No, that's not correct; you forgot to brush the back of your hair," while physically guiding Emily to brush the back of her hair). These particular tasks were selected because it was reported that problem behavior occurred when Emily made a mistake and was corrected, and these tasks had a high likelihood of requiring correction. Contingent on precursor or target behavior, the analyst stopped presenting demands, turned Emily's music back on, and allowed Emily to direct the analyst's behavior again. We describe Emily's contingency as escape to music and child-directed interaction.

[5] No precursors were reported for Jonah.

Jeff. Jeff's control condition included free access to YouTube and the absence of any demands. In the test condition, the analyst paused his YouTube video and instructed him to complete a vocational counting and packaging task. This particular task was selected because a large portion of Jeff's educational program focused on vocational training, and his team reported that this task was frequently assigned to him and frequently associated with problem behavior. Contingent on precursor or target behavior, the analyst terminated the vocational task demand and allowed Jeff to access YouTube again. We describe Jeff's contingency as escape to YouTube.

Dylan. Dylan's control condition included free access to preferred toys and the absence of any demands. In the test condition, the analyst removed Dylan's toys and attempted to take his temperature with a forehead thermometer. We selected this demand because Dylan was reported to engage in problem behavior when presented with any routine hygiene tasks (getting dressed, getting a haircut, letting someone check his ears or take his temperature, etc.) Of these tasks, taking his temperature was the most practical to include in the analysis because it did not require him to undress and it did not require the analyst to use any sharp tools. Contingent on precursor or target behavior, the analyst stopped presenting the thermometer and provided Dylan with access to his toys again. We describe Dylan's contingency as escape to toys.

Chloe. Chloe's control condition began with her socks and shoes off. During her control condition, she was allowed to put on her socks and shoes in the manner that she chose, including engaging in ritualistic behaviors such as opening and closing the Velcro straps multiple times in a row. The analyst responded to all of Chloe's initiations, and did not interrupt Chloe's ritualistic behavior or ask her to hurry up. During the test condition, the analyst told Chloe that she needed to help Chloe put her shoes on because it was taking too long. The analyst reached out and

attempted to touch Chloe's shoes. Contingent on precursor or target behavior, the analyst stopped prompting Chloe and allowed her to engage in ritualistic behavior with her shoes again. Putting on and taking off shoes was selected as a demand because Chloe was reported to engage in prolonged rituals with all dressing tasks, and interrupting any of these rituals could evoke problem behavior. We describe Chloe's contingency as escape to rituals (e.g., Rispoli, Camargo, Machalicek, Lang, & Sigafoos, 2014).

Standard Analysis. The standard analysis 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 analyses as possible: session duration, analysis location, analyst, type of attention, specific tangible items, and specific demands. The standard analysis included all of the same stimuli used in the IISCA, but responses topographies and consequences were not synthesized.

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 arm's 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 (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 analysis. 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 separate (e.g., Moore, Mueller, Dubard, Roberts, & Sterling-Turner, 2002). In other words, problem behavior in the tangible condition produced tangibles *and nothing else*.

Play condition. During this condition, preferred items 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 the participant requested. The preferred items were the same items evaluated in the tangible condition. If a tangible condition was not included in the analysis, the participant was provided with items that teachers reported were preferred. These were provided because the play condition

in the standard analysis typically includes access to toys (Hanley et al., 2003; Iwata et al., 1982/1994). Problem behavior produced no stimulus change.

Escape condition. The same demands presented in the IISCA were presented during this condition. Contingent on problem behavior, 30 s 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 (i.e. problem behavior in the escape condition produced escape *and nothing else*).

Standard Analysis of Precursors (Mason and Riley). The standard precursor analysis was identical to the standard analysis described above, except that any precursors that had been reinforced in the IISCA were also reinforced in this analysis. This means that the only difference between the IISCA and the standard precursor analysis was the synthesis or isolation of consequences. A standard precursor analysis was conducted with any participant for whom precursors were the only response topography observed in the standard analysis (i.e. no problem behavior occurred in any standard condition, but precursors did occur). Mason and Riley were the only two participants who met this criterion.

Results and Discussion

The IISCA was differentiated for 9/9 or 100% of participants, and the standard analysis was differentiated for 4/9 or 44% of participants (see Table 4). The standard analyses of precursors conducted with Mason and Riley were also both differentiated. Mean duration for the IISCA was 28 min (range 15 – 70 min; *SD* 16), and mean duration for the standard analysis was

90 min (range 36 – 200 min; *SD* 49).[6] Thus, the IISCA was differentiated more often than the standard analysis and was more efficient in terms total analysis time required. These findings are similar to those of Jessel et al. (under review) regarding the efficiency and control afforded by the IISCA.

An analysis was considered differentiated if rates of problem behavior in one or more test conditions were elevated relative to rates in the control condition. We observed three distinct patterns with regard to the standard analysis: (a) no problem behavior occurred during any condition of the standard analysis; (b) problem behavior occurred but was uncontrolled in the standard analysis; (c) problem behavior was consistently elevated in one or more test conditions relative to the play condition. The first two patterns were considered undifferentiated; the third pattern was considered differentiated. We present results as grouped by these three patterns.

The data for three participants (Diego, Mason, and Riley) fall into the first pattern mentioned above in which no problem behavior occurred during the standard analysis. Their standard analyses were therefore considered undifferentiated (see Figure 1). The IISCAs for these participants indicated a functional relation between problem behavior and escape to tangibles and attention (Diego, Mason) or escape to tangibles (Riley). Following the absence of any problem behavior or precursors in the standard analysis, we replicated the results of the IISCA for Diego and verified that the functional relation we had first detected in the IISCA was in fact still operating. Following the absence of problem behavior but the presence of precursors in the standard analysis for Mason and Riley, we conducted a standard precursor analysis with both of these participants. Mason's precursor analysis was differentiated for escape, which was one of the reinforcers included in his IISCA. Riley's precursor analysis was differentiated for escape and tangible items, which were both of the reinforcers included in his IISCA.

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

Problem behavior occurred during the standard analysis but was not elevated in any particular test condition relative to the play condition for two participants (Kyle and Jonah). Their standard analyses were therefore both considered undifferentiated (see Figure 2). Kyle's IISCA indicated a functional relation between problem behavior and escape from an unscheduled task to a preferred, predictable schedule. Jonah's IISCA indicated a functional relation between problem behavior and escape to attention, tangibles, and access to motor stereotypy. By contrast, during Kyle's standard analysis, we observed problem behavior in one alone session and one tangible session. No problem behavior was observed during any other sessions. During Jonah's standard analysis, we observed problem behavior at varying rates in every condition.

The standard analysis was differentiated for the remaining four participants (see Figure 3). Dylan's IISCA and standard analysis detected the same two reinforcers: escape and tangibles. For Emily and Chloe, the standard analysis detected one of the reinforcers that had been synthesized in the IISCA. Emily's IISCA identified a functional relation between problem behavior and escape to tangibles and attention; her standard analysis identified escape only. Chloe's IISCA identified a functional relation between problem behavior and escape to rituals; her standard analysis identified escape and no problem behavior occurred in any other condition. Access to rituals was not evaluated in the standard analysis because this type of idiosyncratic reinforcer is not usually included in a standard analysis. In Jeff's case, the IISCA identified a functional relation between problem behavior and escape to tangibles; his standard analysis, however, identified attention as a reinforcer. Although problem behavior occurred in other test conditions, the attention condition was the only condition in which problem behavior reliably occurred at higher rates than in the play condition.

One possible reason that the IISCA was differentiated more often than the standard

analysis may be that problem behavior for some participants was maintained by interactions between variables. Diego's outcomes suggest 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. His problem behavior was not sensitive to the isolated variables of removing tangible items, presenting demands, or withholding attention in the standard analysis. The fact that problem behavior for Kyle and Jonah was controlled and differentiated in the IISCA but not in the standard analysis also suggests the presence of important interactions. The 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 analysis did not reliably evoke problem behavior for Kyle; the play condition did not reliably suppress it for Jonah.

There are a number of other reported instances in which a synthesis of contingencies reliably produced 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; Mann & Mueller, 2009; Mueller, Sterling-Turner, & Moore, 2005; Sarno et al., 2011). The results for these three participants 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 between variables. A limitation to be noted, however, is that Jonah's standard analysis may also indicate maintenance by automatic reinforcement. It is possible that problem behavior was suppressed in the IISCA control condition because the arranged stimuli effectively competed with automatic sources of reinforcement, and not because problem behavior was maintained by social consequences.

A second possible reason for the higher number of differentiated IISCAs may be that we

included precursors *and* problem behavior in the IISCA contingency class, but excluded precursors from the standard analysis. This appeared to be the case for 2 out of the 5 cases in which the standard analysis was undifferentiated. Precursors were reported to occur, were observed during Mason and Riley's standard analyses, and were differentiated in the standard precursor analyses conducted with these two participants. We think these results further demonstrate the value of synthesizing carefully selected and ecologically relevant stimuli in functional analyses of problem behavior. When antecedents were the only variable synthesized in the standard analysis, the analysis was differentiated for four participants. When antecedents *and* response topographies were synthesized in the standard precursor analysis, this number increased to six participants. When antecedents, response topographies, *and* consequences were synthesized in the IISCA, results were differentiated for all nine participants. This pattern shows that the probability of a differentiated analysis increases as the number of participant-specific synthesized variables increases.

For the four participants for whom both analyses were differentiated, the IISCA and standard analysis detected all of the same reinforcers in one case (Dylan), one of the same reinforcers in two cases (Emily, Chloe), and completely different reinforcers in one case (Jeff). These outcomes are similar to those reported by Fisher et al. (in press) in which both analysis formats detected some (but not all) of the same reinforcers in most cases. There are several possible ways to interpret these outcomes. Fisher et al. provided an interpretation that compared the two analysis outcomes to each other to determine the extent to which the IISCA agreed with the standard analysis. In other words, these authors used the standard analysis as an answer key of sorts against which to judge the validity of the IISCA. They concluded that the IISCA did not yield valid information because in each case it included at least one reinforcer that was not

detected by the standard analysis. This interpretation assumes that the standard analysis is a truth-bearing criterion that provides the correct answer regarding the reinforcers that maintain problem behavior, and analyses that provide different information must be incorrect. This logic has precedent; for instance, numerous studies have evaluated descriptive assessments by judging them against a standard functional analysis (Camp et al., 2009; Hall, 2005; Iwata, DeLeon, & Roscoe, 2013; Lerman & Iwata, 1993; Mace & Lalli, 1991; St Peter et al., 2005, Thompson & Iwata, 2007). Using the standard analysis as an answer key in such comparisons makes sense because a descriptive assessment cannot demonstrate a functional relation; a functional analysis can. However, the same logic does not hold when comparing two functional analyses to each other. The IISCA and standard analysis are both experimental and therefore both capable of demonstrating a functional relation.

When two analyses yield different outcomes, rather than assume the veracity of one analysis based on the fact that it has been applied more often, a more pragmatic strategy may be to compare the relative efficacy of treatments designed from sets of differentiated analyses. Do both treatments eliminate problem behavior? Do both treatments establish an appropriate alternative response? These questions are especially important given that the purpose of a functional analysis is to develop an effective function-based treatment for problem behavior. The tactic of examining treatment data to affirm (or reject) functional analysis conclusions has been successfully used by several authors. For instance, Smith et al. (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, Dozier,

Neidert, Jowett, and Newquist (2014) reported two cases in which treatment based on the results of a functional analysis was not effective in eliminating problem behavior. Subsequent analyses determined that some interactions between reinforcers had not been detected by the functional analysis (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 only when mands for *all* reinforcers were acquired, suggesting that the reinforcers included in the IISCA were all relevant parts of the contingency maintaining problem behavior.

Rather than attempting to interpret differentiated sets of analyses by comparing them to each other in the absence of treatment data, we conducted a second study to evaluate relative treatment efficacy. In Study 2 we compared function-based treatments developed from the IISCA and standard analysis to determine which treatment was more effective in eliminating problem behavior and establishing an appropriate communication response.

Study 2: Comparison of Function-Based Treatments

We directly compared IISCA-based and standard analysis-based functional communication training (FCT) plus extinction (EXT) treatments for problem behavior. We evaluated each treatment according to the outcomes of (a) eliminating problem behavior and (b) generating an appropriate functional communication response (FCR). Each participant experienced an equal number of treatment sessions in each condition. Similar to Study 1, our purpose was to see which condition was more effective given the same number of sessions (not to continue modifying treatment components until both treatments were effective).

Method

Participants and Setting. Emily, Jeff, Chloe, and Dylan participated in this study[7]. All treatment sessions were conducted by the same analyst who conducted their functional analyses. The same stimuli that had been included in the relevant functional analysis condition were also used in treatment sessions.

Response Definitions, Measurement, and Inter-observer Agreement (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), prompted FCRs, 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 two to three 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 minimum requirement was met *and* rates of problem behavior and

[7] All other participants from Study 1 also received treatment and consultation after completing the study.

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 access to the multiple reinforcers for problem behavior identified in the IISCA (Hanley et al., 2014). FCT developed from the standard analysis involved teaching an FCR that produced 30 s access to the isolated reinforcer for problem behavior identified in the standard analysis. We signaled the different FCT conditions with color-correlated cards approximately 22 x 28 cm (for participants who communicated vocally) or color-correlated 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 functional analysis upon which the treatment was based; (b) the participant emitted the corresponding FCR; (c) the analyst reinforced the FCR by delivering the reinforcer(s) that had been delivered in that particular functional analysis. 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 in both conditions was placed on extinction; the particular reinforcers that were synthesized during IISCA-based FCT could all be withheld at the

same time (e.g., escape extinction and tangible extinction may both be implemented simultaneously).[8] Upon completion of the study, all participants continued with successful treatments, and we expanded the scope of treatment sessions to include a number of other evocative events beyond the restricted set that had been used in their functional analyses.

Emily. The FCR taught during IISCA-based FCT was *my way please*; the FCR taught during standard-based FCT was *take a break please*. For both FCT conditions, the establishing operation 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, the phrase "my way please" produced 30 s 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 establishing operation was presented during standard-based FCT sessions, the phrase "take a break please" produced 30 s 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 2 feet to make the delivery of escape more salient. After 30 s, the analyst approached Emily again and instructed her to return to work.

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. The FCR taught during IISCA-based FCT was *my way;* the FCR taught during standard-based FCT was *let's talk*. 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,

[8] In Emily's case in which attention, tangible, and escape 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.

then gestured to "way" and waited for Jeff to push that button). These gesture prompts were faded on 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 establishing operation for IISCA-based FCT involved pausing Jeff's YouTube video and instructing him to return to his vocational counting task. The phrase "my way" produced 30 s escape from the vocational task plus access to videos on YouTube. After 30 s, the analyst paused the YouTube video and instructed Jeff to resume his vocational task. The establishing operation for standard-based FCT involved the analyst telling Jeff that she had some work to do, and then turning away from him. The phrase "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 iPad, 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 (i.e., saying "mom" when the analyst asked who Jeff was going to eat pizza with later). After 30 s, the analyst told Jeff she had to get back to her work and turned away from him again.

Dylan. Dylan experienced three FCT conditions because his standard analysis indicated control by two separate reinforcers. The FCR taught during IISCA-based FCT was *my way*; the FCR taught during standard-based FCT for tangibles was *toys please;* the FCR taught during standard-based FCT for escape was *not now*. We will refer to these latter two conditions as tangible-based FCT and escape-based FCT throughout the rest of the paper.

The establishing operation for IISCA-based FCT involved telling Dylan he needed to put

away his toys and come get his temperature taken. The phrase “my way” produced 30 s escape from the thermometer and access to the preferred toys. The establishing operation 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). The phrase “toys please” produced 30 s access to the toys. Attention was not provided during this 30 s interval, to ensure that toys were the only reinforcer that Dylan accessed. The establishing operation 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. The phrase “not now” produced 30 s escape from the demand to get his temperature taken. Toys and attention were not provided during this reinforcement interval, to ensure that escape was the only reinforcer Dylan accessed.

Chloe. The FCR taught during IISCA-based FCT was *my way please*; the FCR taught during standard-based FCT was *take a break please.* The establishing operation for both conditions involved the analyst attempting to help Chloe put her shoes on. During IISCA-based FCT, the phrase *my way please* produced 30 s escape from the analyst’s prompts to put the shoes on, as well as access to engaging in ritualistic behavior with the shoes. After 30 s, the analyst reached forward again and told Chloe she needed to help her with the shoes. During standard-based FCT, the phrase *take a break please* produced 30 s 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. After 30 s, the analyst presented the shoes to Chloe again and told her that she was going to help put them on.

Results and Discussion

IISCA-based FCT was effective for all four participants. It was more effective than standard-based FCT for Emily and Jeff; it was equally as effective as standard-based FCT for Chloe and Dylan. Emily and Jeff's treatment data are depicted in Figure 4. 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-based FCT for both of these participants. Mean rate of problem behavior for Emily was 0.04 per min during IISCA-based FCT, compared to 1 per min during standard-based FCT. The problem behavior observed during IISCA-based FCT was two instances of screaming; the problem behavior observed during standard-based FCT included screaming, SIB, aggression, and disruption (throwing items). Mean rate of problem behavior for Jeff was 0 per min during IISCA-based FCT, compared to 0.6 per min during standard-based FCT. Problem behavior observed during standard-based FCT was flopping to the ground. Jeff's mean rate of problem behavior during the attention condition of the standard analysis was 0.2 per min, which means that his rate of problem behavior actually increased during standard-based FCT.

Neither Emily nor Jeff acquired the standard-based FCR. Mean rate of independent FCR use during IISCA-based FCT was 0.6 per min for both Emily and Jeff, compared to 0.06 per min during standard-based FCT for Emily and 0 per min for Jeff. During standard-based FCT sessions, Emily often remained silent when prompted to emit the FCR and did not respond until several prompts had been delivered; Jeff attempted to access the menu settings on his iPad and load the page that displayed the IISCA-based FCR instead. These types of "hacking" attempts

did not occur during IISCA-based FCT sessions. It should be noted that both Emily and Jeff did engage in many prompted instances of the standard-based FCR, and thus they contacted the reinforcement contingency many times each session. However, independent use of the standard-based FCR was never established.

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.

The presence of interactions between contingencies may have contributed to the fact that IISCA-based treatment was more effective than standard-based FCT for Emily and Jeff. It is possible that interactions were present and went undetected even when the standard analysis was differentiated (e.g., Mann & Mueller, 2009; Payne et al., 2014). For example, Emily's standard analysis 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 the standard analysis indicates that these establishing operations were not sufficient to evoke problem behavior in and of themselves, but it does not rule out the possibility that these stimuli 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 analysis.

It is important to note that the escape condition of Emily's standard analysis contained the same synthesized EOs as her IISCA test condition: no music was present, child-directed interaction was not allowed, and demands were presented. When escape was delivered in the standard analysis and during standard-based FCT, the EOs for music and child-led interaction remained. It seems plausible that problem behavior persisted during standard-based FCT because those additional establishing operations were still in place and not all reinforcers were delivered. A post hoc within-session analysis of Emily's data indicates that problem behavior continued throughout the reinforcement interval in the escape condition of the standard analysis and during standard-based FCT.[9] In other words, during the standard analysis and its correlated treatment, problem behavior persisted in the presence of the putative reinforcer, which suggests that one or more EOs for problem behavior were still in place (Payne et al., 2014; Roane, Lerman, Kelley, & Van Camp, 1999). By contrast, problem behavior ceased immediately and did not persist throughout the reinforcement interval in the IISCA test condition, providing further support for the importance of the synthesized contingency.

For the two cases in which both treatments were equally effective, it appears that the IISCA may have included a putative reinforcer that was not in fact a reinforcer for problem behavior (Chloe) or that the synthesis of the two individual reinforcers was not critical (Dylan). These stimuli were synthesized in the IISCA because their co-occurrence was prevalent in typical environments. However, treatment data indicate that the individual stimuli themselves or

[9] This was determined by reviewing the data streams to note when the onset and offset of each reinforcement period was marked, and whether problem behavior was scored during this period.

their co-occurrence were not relevant to the particular problem behavior in question (e.g., Thompson & Iwata, 2001; Thompson & Iwata, 2007).

Fisher et al. (in press) note two possible concerns with including incidental stimuli in a functional analysis: (a) the resulting function-based treatment may be needlessly cumbersome to implement because of the extra consequences provided; (b) providing escape when it is not a necessary part of the contingency may result in less instructional time for the individual. Regarding incidental stimuli producing a treatment that is cumbersome to implement, this did not seem to be the case for either participant. Dylan's escape-based FCT treatment was actually *more* cumbersome 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 means caregivers would need to be trained in two different treatments. This seems more cumbersome than a synthesized treatment that we know to be equally effective. Regarding the issue of providing escape when it is not necessary to do so, this did not apply to Dylan or Chloe because both analyses for both of these participants detected escape as a reinforcer. However, it is worth pointing out that even if

escape is not a functional reinforcer for problem behavior, it is extremely difficult to deliver other reinforcers such as attention or tangible items without also delivering a brief period of escape. For example, it is likely that an individual will pause a task while consuming an edible, while receiving attention from a caregiver, and certainly while accessing a tangible reinforcer such as an iPad. In other words, escape often occurs anyway when the individual is provided with the functional reinforcers for his or her problem behavior, and including escape as an incidental contingency therefore does not seem too concerning.

Based on Dylan and Chloe's data, we suggest that the inclusion of incidental stimuli in the IISCA was not problematic and that the IISCA-based treatment may in fact be easier to implement in typical, less-controlled contexts. It seems more problematic to overlook possible interactions between reinforcers and assume that any main effects detected must be the only effects operating. Such omissions occurred in Emily and Jeff's cases; their outcomes with standard-based FCT show that missing important controlling contingencies in analyses and derived treatments yielded treatments that did not reduce problem behavior. This outcome is far more troublesome than that observed when possibly incidental contingencies are included. We also suggest that it is probably not necessary to determine during the analysis whether an IISCA has included some incidental stimuli alongside functional reinforcers; this can be determined during treatment. For example, after an omnibus FCR is acquired, a next step may be to teach specific FCRs for the individual reinforcers that are being delivered. Through this process, it may become clear that certain stimuli are not functional reinforcers because the individual does not acquire the specific FCR for that item or rarely emits that FCR. In other words, treatment based on an IISCA can begin immediately even if such questions are unanswered; individual components of the contingency can be evaluated at a later point without delaying treatment.

General Discussion

The results of our Study 1 revealed that the IISCA was differentiated more often than the standard analysis (100% versus 44% of applications) and was more efficient. Our results regarding the speed and efficacy of the IISCA in identifying the function of problem behavior are similar to those reported by others who have evaluated the IISCA (Ghaemmaghami, et al., 2015; Hanley et al., 2014; Jessel et al., in press; Santiago et al., 2015). Our results regarding the types of reinforcers detected by each analysis format were similar to those reported by Fisher et al. (in press): in most cases, differentiated sets of analyses implicated slightly different or very different reinforcers for problem behavior. We compared function-based treatments in Study 2 and found that IISCA-based treatment was effective in all four cases and standard-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.

Though our results are similar to those of Fisher et al. (in press), our interpretation of these results differs significantly in a number of important ways. Fisher et al. state that maintenance by interactive effects is the underlying assumption of the IISCA and that certain response patterns should therefore be observed when comparing the IISCA to the standard analysis. They describe two possible response patterns that could indicate the presence of interactions between contingencies: a) problem behavior occurs in the IISCA and does not occur at all in the standard analysis; b) problem behavior occurs in the IISCA and in the corresponding isolated test conditions of the standard analysis. Diego's data are an example of the first pattern; Dylan's data are an example of the second. None of the participants in Fisher et al. displayed either of these two response patterns, and the authors concluded that the IISCA was therefore

inaccurate and contained functionally irrelevant stimuli. By contrast, we suggest that the validity of one functional analysis cannot be determined by comparing it to another functional analysis, but rather by comparing the resulting treatments of each analysis. We think this pragmatic approach is preferable because it judges the value of an analysis by the extent to which the analysis produces effective action.

A second assertion offered by Fisher et al. is that interactions between contingencies should produce more robust reinforcement effects, which means that problem behavior should occur at higher rates in the IISCA than in the standard analysis. However, there are a number of reasons why this may not be the case. For example, rates of responding in any test condition can be influenced by variables such as the duration of the reinforcement interval (Fisher et al., 1996). Responding during a test condition may also persist through the reinforcement interval (Payne et al., 2014; Roane et al., 1999), which would produce higher response rates than a test condition in which problem behavior immediately ceased when the reinforcer was provided. For example, for our participant Emily, rates of problem behavior were higher in the escape condition of the standard analysis than they were in the test condition of the IISCA because problem behavior persisted during the escape interval of the standard analysis (but ceased immediately during the reinforcer interval of the IISCA). Emily's subsequent treatment analysis revealed that providing escape by itself was not sufficient to eliminate problem behavior, which suggests that higher rates were observed in the standard analysis because a synthesis of reinforcers was *not* provided. A similar point was made by Roane, Lerman, Kelley, and Van Camp (1999). These authors demonstrated that when a functional reinforcer is provided for problem behavior, responding typically ceases immediately. When all functional reinforcers are delivered in a test condition, responding should therefore probably conform to the optimal rate produced by the duration of

the reinforcement interval (e.g., 2 per min given a reinforcer interval of 30 s). There is no reason that interactions between reinforcers should produce higher response rates; it is more likely that higher response rates in a test condition suggest that a functional reinforcer has not been provided.

The IISCA does not assume that problem behavior is maintained primarily by interactive effects (though interactions certainly occur in nature). Rather, the emphasized and demonstrated benefits of the IISCA include a significantly shorter analysis duration and a greater degree of control over problem behavior (Jessel et al., under review), the development of effective interventions that are also socially valid (Hanley et al., 2014; Santiago et al., 2015), and the ability to evoke problem behavior that is sensitive only to interactions (Ghaemmaghami et al., 2015; Hanley et al., 2014). It seems unwarranted and premature to dismiss the utility of conducting an IISCA based on the conclusion that its results do not match those of the standard analysis or do not always suggest interactive effects, particularly given that the data from Study 2 indicate that the IISCA produced effective treatment more often than the standard analysis. It also does not seem appropriate to evaluate the validity of the IISCA based on whether it produces higher levels of responding than another analysis, given that there are a number of possible reasons for higher or lower response rates between analysis conditions.

Our results suggest that the type of precision afforded by the IISCA plays an important role in analyzing and treating problem behavior. When designing a functional analysis, perhaps it is more important to precisely emulate the specific establishing operations and reinforcers that occur together in the natural environment (see Table 3) than it is to precisely isolate the impact of each individual contingency suspected of influencing problem behavior. The IISCA was differentiated for each participant, IISCA-based FCT was effective for all participants in Study 2,

and we saw no detrimental effects in the two cases in which the IISCA appeared to include incidental stimuli. By comparison, the standard analysis was undifferentiated for five participants, which means we would have difficulty developing an effective function-based treatment if we were to rely only on the standard analysis for those five participants. For the four participants for whom the standard analysis *was* differentiated, the function-based treatment developed from its results was not effective in two cases. Thus, the standard analysis produced effective action (a differentiated analysis that resulted in effective treatment) for only two of nine participants.

It is interesting to note that the percentage of differentiation we obtained with the standard analysis (44%) is similar to that reported by Hagopian et al. (2013) in which only 47% of standard analyses were differentiated on the first attempt. Reviews of the published functional analysis literature may show a much higher percentage of differentiation (e.g., 96% in Hanley et al., 2003), but this is most likely because undifferentiated analyses are rarely published. There are a considerable number of ways in which the standard analysis may be modified when differentiated results are not initially obtained (such as including precursors in the contingency class), and it is possible that continued attempts to modify and refine the standard analysis would have produced differentiation and effective treatment in more cases (as was evident in Hagopian et al.). However, the process of modifying and re-running the analysis can be time consuming and may require a level of expertise that is not easily accessible outside of specialized hospital or clinic settings. 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,

differentiated analysis and an effective treatment; it is not likely to impede effective action. Considering that many practitioners report rarely conducting functional analyses (Oliver et al., 2015; Roscoe et al., 2015), the extent to which the IISCA or any other analysis format is readily used by practitioners will continue to be an important area of study.

Several important areas of future research are occasioned by questions regarding which types of precision are most important in a functional analysis. A first area of research may be to identify the impact of informing analyses with qualitative details rendered from open-ended interviews versus populating the analysis with generic variables. Is a differentiated analysis more likely when *any* common, generic variables are synthesized, or only when the synthesized variables are carefully selected based on participant-specific details? A second area of research may be the prevalence of problem behavior maintained by interactions between contingencies. We do not know how often this may occur, which means that we cannot say whether it is beneficial to look for interactions first before looking for main effects, or vice versa. Our data demonstrate that the IISCA can reliably evoke problem behavior maintained by interactions between contingencies that the standard analysis may miss, but we do not know in how many cases this will be of value. A third important research aim 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? Are there more long-term advantages of relying on synthesized or isolated contingencies? 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.

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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	Bolting, 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

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
Riley	Hitting, kicking, or biting others; pulling hair; hand-to-head SIB; throwing objects	Whining; body-tensing
Mason	Hitting or kicking others; hitting or throwing objects	Whining; grimacing; body slam in chair
Kyle	Grabbing others; hand-to-head SIB	Whining; biting lip
Jonah	Bolting; flopping and hiding (flop plus legs or shoulders under an object); climbing on furniture	–
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!"

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
Riley	Allow Riley to watch YouTube and play with toys; do not present medicine	Pause YouTube, remove toys, and instruct Riley to take his medicine
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.
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 mistake 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 / take off shoes her own way without interrupting her	Interrupt shoe ritual and help Chloe put on / take off 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

Table 4

Functional Analysis Outcomes

Participant	Function via IISCA	Function via Standard	Function via Standard Analysis of Precursors
Diego	Escape to toys, attention	Undifferentiated	–
Riley	Escape to YouTube	Undifferentiated	Escape, YouTube
Mason	Escape to toys, preferred conversation, answers	Undifferentiated	Escape
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	–

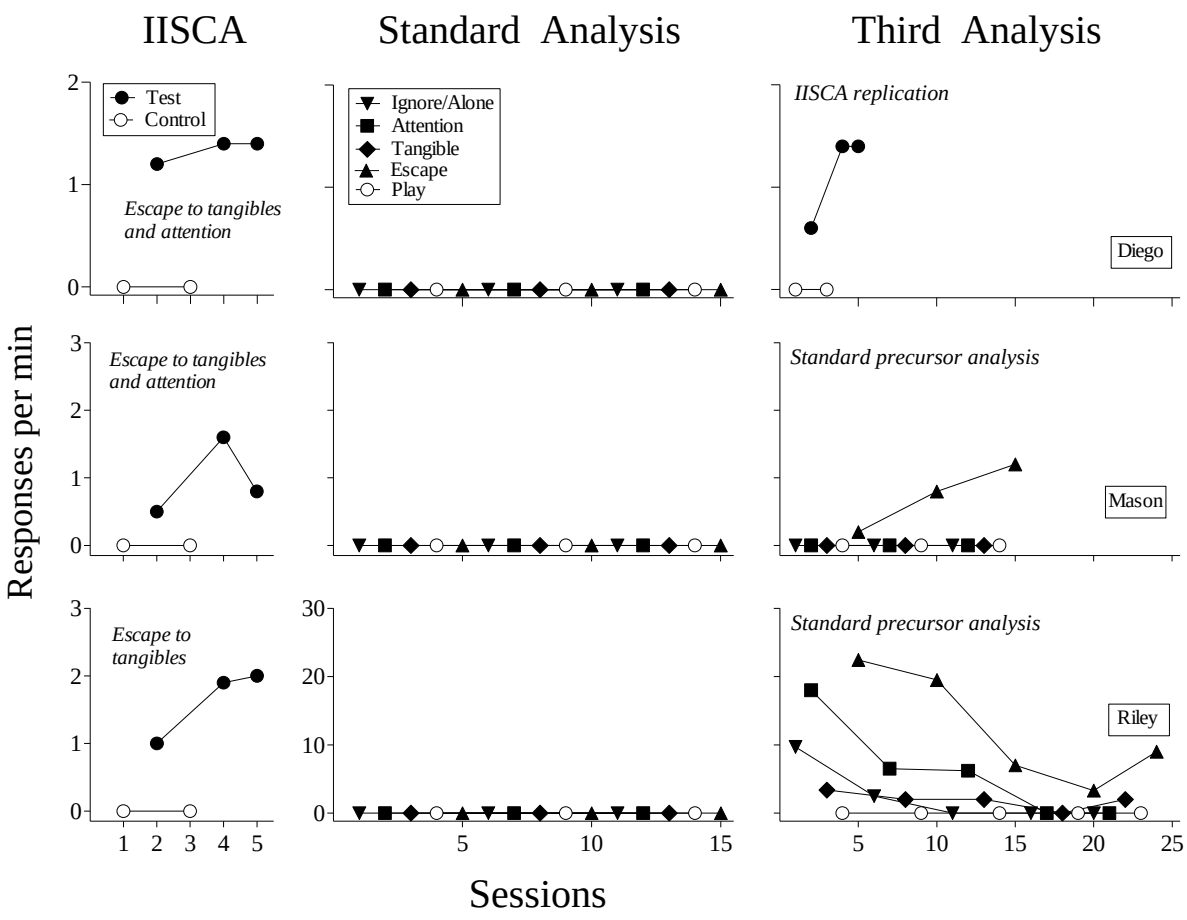

Figure 1. IISCA, standard analysis, and follow-up analyses for Diego, Mason, and Riley. The y-axis denoting *responses per min* refers to problem behavior and precursors in the IISCA and precursor analyses, and problem behavior only in the standard analysis.

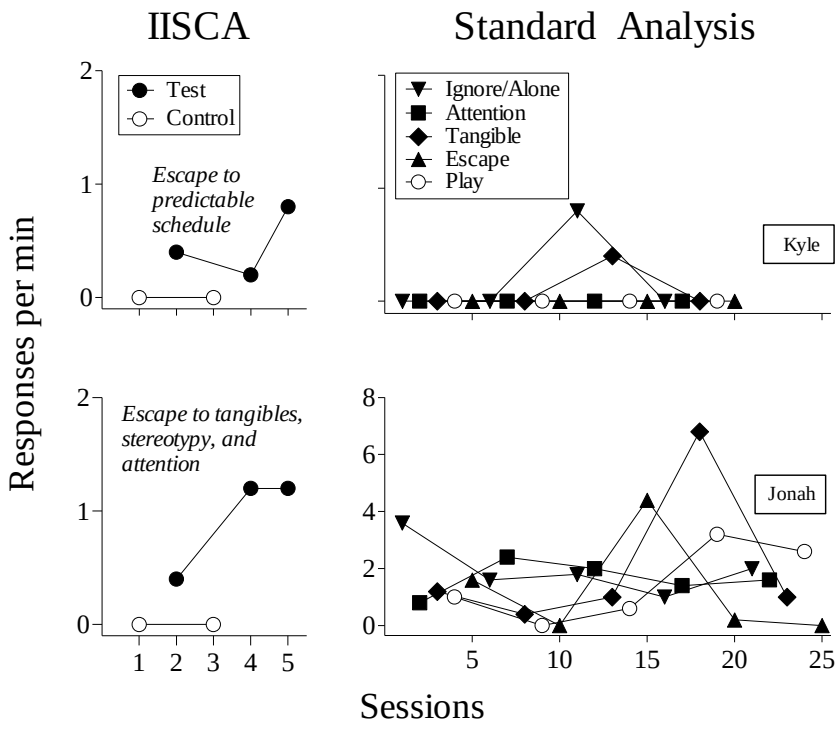

Figure 2. IISCA and standard analysis results for Kyle and Jonah. The y-axis denoting *responses per min* refers to problem behavior and precursors in the IISCA, and problem behavior only in the standard analysis.

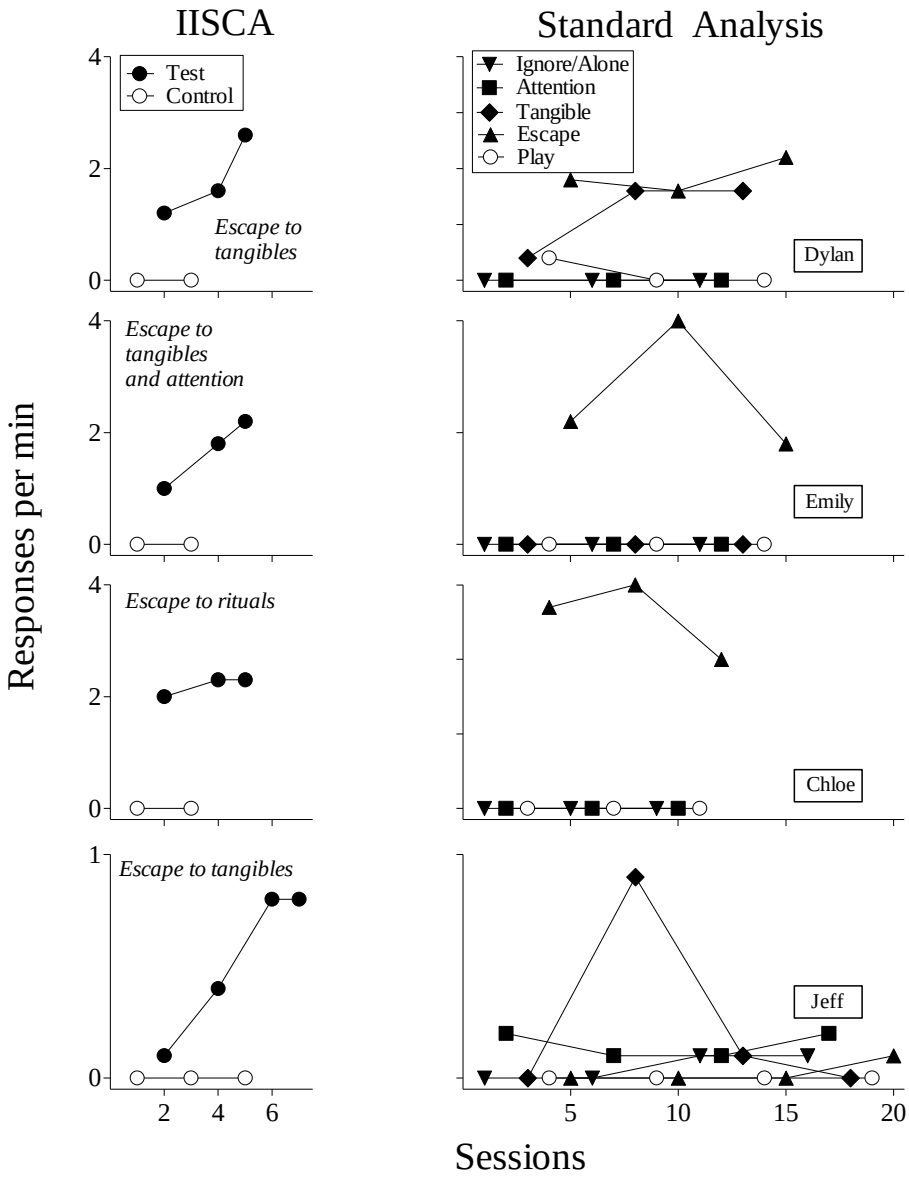

Figure 3. IISCA and standard analysis results for Dylan, Emily, Chloe, and Jeff. The y-axis denoting *responses per min* refers to problem behavior and precursors in the IISCA, and problem behavior only in the standard analysis.

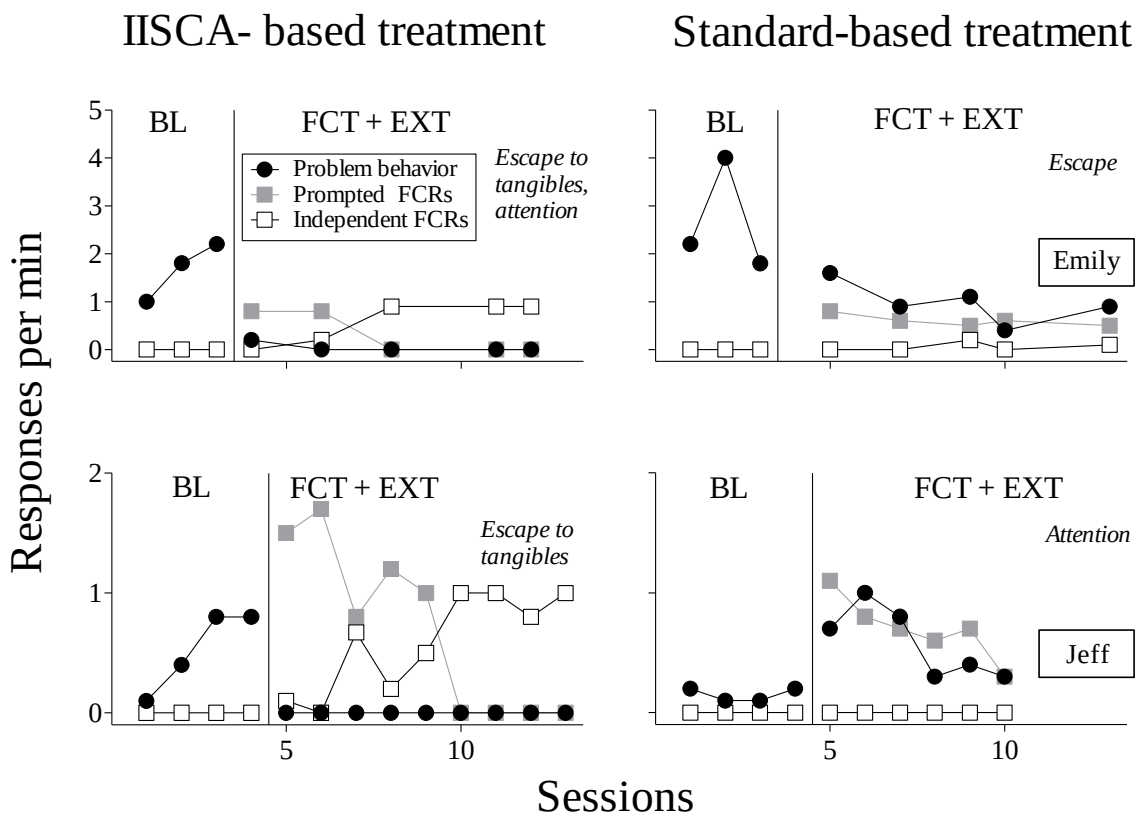

Figure 4. Rate of problem behavior, prompted FCRs, and independent FCRs during IISCA-based FCT and standard-based FCT treatment results for Emily and Jeff.

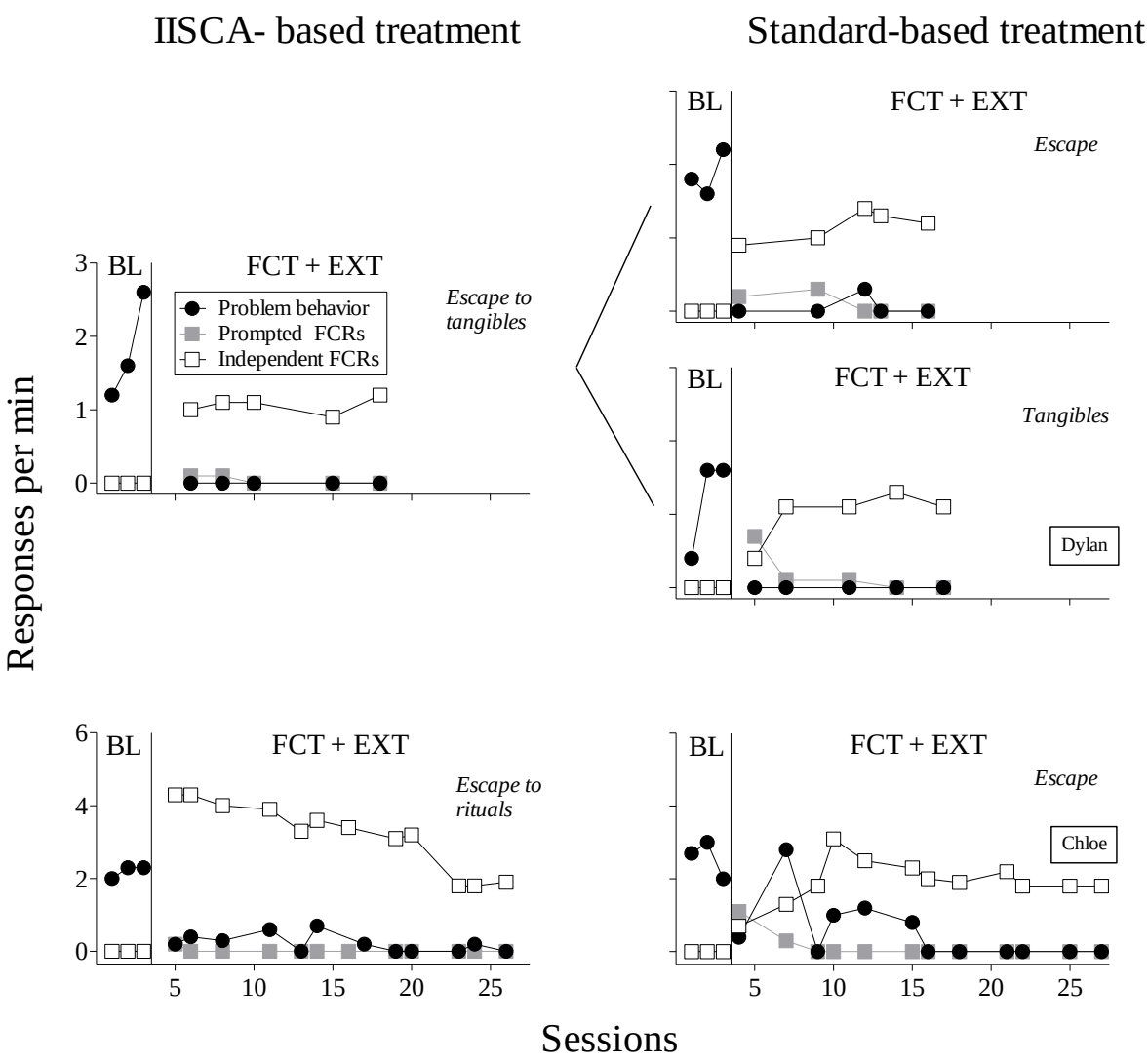

Figure 5. Rates of problem behavior, prompted FCRs, and independent FCRs during IISCA-based FCT and standard-based FCT treatment results for Dylan and Chloe.