



Further comparison of isolated and synthesized contingencies in functional analyses

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Recent research on functional analyses (FAs) has examined the extent to which problem behavior is maintained by single (isolated) or combined (synthesized) reinforcement contingencies. Outcomes of these analyses might differ depending on the sources of information that are used to inform contingencies included in test conditions. The purpose of the current study was to compare the outcomes of isolated FAs and synthesized contingency analyses (SCAs) with 3 participants. Conditions in both analyses were informed by interviews and both unstructured and structured observations. Problem behavior for all 3 participants was maintained by 1 or 2 isolated reinforcers. Results suggested false-positive SCA results for 2 participants. For 1 participant, a second isolated reinforcer was identified following the SCA, indicating the induction of a novel function. Implications for the use of isolated and synthesized consequences are discussed, as well as the predictive validity of the assessments that are used to inform them.

Key words: assessment, functional analysis, isolated contingencies, synthesized contingencies, validity

Functional analyses (FAs) are commonly used for demonstrating a functional relation between problem behavior and isolated reinforcement contingencies (for reviews see Beavers et al., 2013; Hanley et al., 2003). The procedures described in the seminal article on FA methodology (Iwata et al., 1982/1994) evaluated putative establishing operations (EOs) and reinforcers in isolation (and will henceforth be referred to as the isolated FA). Modifications to the isolated FA have incorporated tests for tangible reinforcement (Day et al., 1988; Mace & West, 1986) and other more idiosyncratic variables as informed by

interviews (e.g., Bowman et al., 2013; Roscoe et al., 2015). Additional modifications to the design, antecedents, and/or consequences may be used to tailor FAs to evaluate specific hypotheses about function and enhance the probability of producing differentiated results (Hagopian et al., 2013). Nevertheless, the core features of the isolated FA methodology have been demonstrated to be effective at identifying the function of problem behavior in hundreds of studies (Beavers et al., 2013; Hanley et al., 2003), with the vast majority indicating maintenance by one or more isolated contingencies.

Another modification that is a marked departure from the isolated FA methodology is the synthesized contingency analysis (SCA), which is intended to emulate the natural environment in which multiple EOs may be simultaneously present and multiple reinforcers may be delivered contingent on problem behavior (Hanley et al., 2014). Within the SCA, a single test condition synthesizes all suspected contingencies endorsed by caregivers during an open-ended interview and brief observation. A control condition makes all putative reinforcers available

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noncontingently. In general, outcomes of treatments based upon SCAs have been effective and efficient (for reviews see Coffey et al., 2020; Slaton & Hanley, 2018), and recent research has suggested that the function of problem behavior can be identified within a single SCA session using within-session analysis (Jessel, Hanley et al., 2018) or latency- and trial-based formats (Curtis et al., 2020; Jessel, Ingvarsson et al., 2018).

It is common for researchers to use the isolated FA as the gold standard for comparison when evaluating other functional assessments, such as the SCA (Tiger & Effertz, 2020). Several such comparative evaluations of isolated FAs and SCAs have indicated a propensity for the SCA to produce false positive results. That is, some consequences in the synthesized contingency were not found to be reinforcers in an isolated FA (Fisher et al., 2016; Greer et al., 2020; Holehan et al., 2020). Fisher et al. (2016) conducted the first direct comparison of the isolated FA and SCA, observing differentiation between rates of problem behavior in the control and at least one test condition in both analyses for four out of five participants, though more quickly for the SCA. However, whereas the SCA included multiple putative reinforcers as the consequence for problem behavior, the isolated FA indicated that these participants' problem behavior was only sensitive to a single type of reinforcer. This finding suggests that the SCA identified one or more extraneous consequences as a reinforcer (i.e., a false positive result). In contrast, in another comparison of the outcomes produced by these two FA formats, Slaton et al. (2017) found that the SCA produced differentiation between the test and control condition for each of nine participants. In contrast, an initial isolated FA did so for only four participants (though differentiation was later achieved for an additional two cases when reinforcement was made contingent on precursor behavior). For five cases, different

functions were identified by the SCA and isolated FA, again suggesting that the SCA identified false positive functions.

More recently, Greer et al. (2020) compared the outcomes of the isolated FA and two SCAs; one that was informed by an open-ended interview of caregivers (i.e., IISCA) and one that included each of the three most commonly identified functions of problem behavior (attention, tangible, and escape; i.e., SSCA). The isolated FA identified one or more functions of problem behavior for 11 out of 12 participants, whereas the two SCAs did so for only 8 out of 12 participants. For seven participants, both SCAs showed differentiation between the test and control condition even though one analysis included all three common functions of problem behavior (including those not endorsed by caregivers). This finding suggests that differentiation between test and control conditions of an SCA does not necessarily indicate that all contingencies included in the test condition contain functional reinforcers. The presence of potential false positive results was further supported by comparison of the results of the SCAs to those of the FA, with the IISCA and SSCA producing false positives in 28% and 40% of cases, respectively. Taken together, the literature comparing SCAs and FAs is mixed, with the study by Slaton et al. (2017) providing support for the SCA methodology, but those by Fisher et al. (2016) and Greer et al. demonstrating poor correspondence between these two approaches. In particular, the study by Greer et al. indicated that using information from the open-ended interview or structured observation to develop the test condition of SCAs may lead to the inclusion of arbitrary contingencies.

One potentially important difference between these studies is the procedures employed when selecting contingencies for inclusion in test conditions of the SCA. The study by Slaton et al. (2017) followed the approach described by Hanley et al. (2014) by using an open-ended caregiver interview. Although not reported by Slaton et al., SCAs

also tend to be informed by unstructured (informal) observations (e.g., Ghaemmaghami et al., 2016; Hanley et al., 2014; Jessel et al., 2016; Jessel, Hanley et al., 2018). Conversely, Fisher et al. (2016) and Greer et al. (2020) used the caregiver interview and a structured observation that systematically manipulated EOs and consequences. A more recent study evaluated the correspondence between the isolated FA and the IISCA (Holehan et al., 2020) but did not specify which type of observation was used. It is possible that mixed results in the comparative literature could be, at least in part, due to differences in the sources of information used to arrange contingencies. For example, it may be the case that the structured observation used in Fisher et al. (2016) and Greer et al. (2020) led to the inclusion of contingencies in the SCA that might not have been identified had they used an unstructured observation or the open-ended interview alone, thereby producing discrepancies between results of the isolated FA and SCA. Thus, the purposes of the current study were (a) to compare the results of the structured and unstructured observations and (b) to compare results of the isolated FA and SCA that included contingencies based on those observations.

Method

Participants

Three children referred to a university-based applied behavior analysis clinic for the assessment and treatment of severe problem behavior served as participants. Participants attended the clinic for 2 hr per day, between 3-5 days per week. Katie, a 3-year-old female diagnosed with generalized convulsive epilepsy, engaged in aggression and self-injurious behavior (SIB). She communicated using gestures and single words. Martin, a 14-year-old male diagnosed with autism spectrum disorder (ASD), engaged in aggression and SIB. He spoke using

multiword sentences. Corey, a 6-year-old female diagnosed with attention-deficit hyperactivity disorder and other specific congenital anomalies, engaged in aggression and spoke using one- or two-word phrases.

Setting and Materials

All sessions were conducted in an individual padded therapy room (approximately 2.7 x 3.0 m), equipped with a one-way observation mirror and a single table and chair. The FA conditions included relevant leisure and demand materials brought from home by the participants' caregivers. Selection of leisure items for inclusion was further informed by a multiple-stimulus without-replacement (MSWO) preference assessment (DeLeon & Iwata, 1996). The isolated FA and SCA included the same preferred leisure materials, demands, and forms of attention across applicable test and control conditions. Caregivers wore an Actpe Ultra Mini Wireless Bluetooth Earpiece that enabled experimenters to vocally communicate with them during the unstructured observation. Experimenters wore different colored vests during all sessions to help promote discrimination between conditions.

Measurement

Trained observers collected continuous frequency data using BDataPro software (Bullock et al., 2017), which were converted into a rate measure (responses per minute). For all participants, *aggression* was defined as forceful contact between the participant's hands, arms, legs, or feet and the experimenter's body from a distance of at least 15 cm. For Katie, aggression also included contact between her nails and any part of the experimenter's skin in an up or down motion. For Katie and Martin, aggression also include contact between the participant's closed fist and any part of the experimenter's hair. For Katie, *self-injurious behavior* (SIB) was defined as closing her fingers

around her hair and pulling forcefully, scraping up or down her face with curved fingers in a fast-paced motion, or inserting any part of her body past the plane of her lips. For Martin, SIB was defined as forceful contact between his hand or another object and his head from a distance of at least 15 cm.

Interobserver agreement was evaluated for at least 30% of all sessions by having two observers simultaneously but independently record data. Each session was divided into 10-s intervals. For each interval, the lower number of responses recorded was divided by the greater number of responses recorded then multiplied by 100 to obtain a percentage. If no responses were recorded by either observer, 100% agreement was coded for that interval. Average percent agreement for the session was calculated by averaging agreement scores across intervals. Agreement coefficients for problem behavior averaged 96% (range, 95% - 96%) for Katie, 98% for Martin, and 98% for Corey. Agreement coefficients for procedural integrity measures (detailed below) averaged 93% (range, 92% - 95%), 96% (range, 95% - 96%), and 97% (range, 96% - 97%) for Katie, Martin, and Corey, respectively.

Procedural Integrity

Procedural integrity was evaluated for at least 30% of all sessions for each participant. Procedural integrity was recorded for reinforcement delivery for all conditions. Correct responses were defined as any instance of reinforcement delivered for 30 s within 5 s of the target behavior for all conditions, with demand delivery and praise for compliance added to the definition of a correct response in the escape condition. Errors of omission were defined as the absence of reinforcement, demand, or praise delivery within 5 s of the target behavior. Errors of commission were defined as any instance in which reinforcement was delivered in the absence of the target behavior, or in

which a reinforcer was delivered that did not match the relevant EO. The number of correct responses was divided by the total opportunities to engage in the target response (i.e., correct responses and errors of omission), and multiplied by 100. Integrity was calculated for reinforcement duration by dividing the total number of seconds reinforcement was delivered by 30 s (i.e., the time that reinforcement should have been delivered) and multiplying by 100. Average integrity was 97% (range, 90% - 100%), 80% (range, 23% - 100%), 97% (range, 78% - 100%), and 90% (range, 74% - 98%) for escape, attention, tangible, and synthesized conditions, respectively. The low range in integrity for attention is a result of sessions in which problem behavior occurred at a low rate. In these sessions, missing reinforcement for just one instance of problem behavior was recorded as an error of omission, yielding low overall integrity. Additional training sessions and review of the operational definitions for problem behavior was conducted with all therapists and data collectors following a session with less than 80% integrity.

Design

Separate multielement designs were used for the isolated FAs and SCAs, and an ABAB reversal design was used to compare the results of those analyses. The order of isolated FAs and SCAs was counterbalanced across participants, and the order of conditions within the isolated FA was randomized for each participant. A control condition was conducted as the first SCA session for each participant followed by a test condition. Test and control conditions alternated for each session thereafter. Single conditions evaluations were conducted following the FA comparison if undifferentiated results were observed in the multielement design. Extended isolated test conditions were conducted until responding decreased to near zero rates or reached a steady state. Reversals

were included when necessary to compare responding in test conditions and an associated control condition.

Open-Ended Interview

Trained graduate students conducted an open-ended interview (Hanley, 2012) with at least one caregiver for each participant, that lasted approximately 25 min. The questions included those listed in the open-ended functional assessment interview described by Hanley (2012), with two additional inquiries: (a) “What are your goals regarding the outcome of our interventions?” and (b) “Are there any medical issues that we should be aware of that may come up during their assessment or intervention sessions? If so, describe the measures that should be taken.” The experimenter used the information gathered from the open-ended interview to identify target behaviors, putative EOs and consequences, preferred stimuli, and participant abilities. The results of the open-ended caregiver interview suggested escape, attention, and tangible items as putative reinforcers for problem behavior for Martin and Corey, whereas only tangible items and attention were indicated for Katie.

Extended Alone

An extended-alone condition was conducted with Katie and Martin to rule out the possibility of automatic reinforcement maintaining SIB (Querim et al., 2013). Self-injury decreased and remained at zero for both participants, confirming maintenance by socially mediated consequences. Based on information gathered from the open-ended interview, aggression was not suspected to be automatically maintained for any of the three participants and was therefore not evaluated as such.

Unstructured Observation

At least one trained graduate student and a Board Certified Behavior Analyst at the doctoral

level conducted one 30-min observation session with each participant and caregiver to identify the antecedent and consequent events correlated with each participant’s problem behavior during naturalistic interactions. This observation also informed the operational definitions of problem behavior, as well as the types of attention and demands provided by caregivers so that the experimenters could include them in subsequent conditions. The procedures for this unstructured observation conformed to the methods described by Fisher et al. (2016). Only the child and their caregiver(s) were present, with the experimenter observing through the observation mirror and delivering prompts via the Bluetooth earpiece. For the first 10 min, an experimenter gave caregivers the following instruction: “In this phase of the assessment, we will be observing interactions between you and [participant name]. We would like you to do the things you normally do, and pretend we are not watching.” Relevant leisure, academic, and/or self-care items (based on reports from the open-ended interview and brought from home) were placed in the session room. If 10 min elapsed and the caregiver had not yet exposed the participant to one or more potential EOs (low attention, restricted leisure item, or task demand), an experimenter prompted the caregiver by providing one or more of the following instructions: (a) “What happens when you give them a task?” (b) “What happens when you take this toy away?” (c) “What happens when you are busy and can’t talk to them?” In each unstructured observation, there was at least one opportunity to introduce the EO for attention, leisure items, and escape.

Structured Observation

Trained graduate students conducted a structured observation with each participant in which putative reinforcement contingencies were systematically presented and their effects on problem behavior evaluated. The procedures

of the structured observation were similar to Fisher et al. (2016) with a few modifications (described below). The session room contained relevant leisure, academic, and/or self-care items that had been identified using the results of the open-ended interview and unstructured observation. The structured observation consisted of a single session, approximately 45 min in duration, in which control and test trials were alternated within the session until each EO had been introduced. Each control and test trial lasted 4 min. Test trials included those with programmed EOs for isolated social positive reinforcement, isolated social negative reinforcement, and all possible combinations of synthesized social positive and social negative reinforcement. EOs were introduced in the following order across all participants, with a control trial between each test trial type: escape; attention and escape; attention, tangible, and escape; tangible and escape; attention and tangible; attention; and tangible. Control trials included continuous noncontingent access to attention without demands following the first three test trials. All control trials thereafter included continuous noncontingent access to both attention and tangible items without demands. This order of control and test trials reduced the probability of carryover effects in which problem behavior might be evoked by the removal of a tangible item in a prior condition. For trials that included social positive reinforcement, the EO consisted of removal of only the reinforcer(s) that the participant was consuming at the start of the trial. For example, if the participant was engaged with a leisure item but not talking with the experimenter, then the experimenter removed only the leisure item and continued to provide attention. If the participant was both engaged with a leisure item and interacting with the experimenter, then the experimenter removed both the leisure item and attention as an EO for social positive reinforcement. The experimenter delivered reinforcement for 20 s contingent on problem

behavior during test trials before reintroducing the EO(s).

Comparison of Isolated FA and SCA

To be included in the isolated FA and SCA, a contingency must have been identified as a putative reinforcer by the open-ended interview and at least one of the observations. In other words, if a putative reinforcer was identified by caregivers but not observed to evoke problem behavior in the unstructured and/or structured observation, then it was not evaluated in an isolated test condition of the isolated FA (Roscoe et al., 2015) or the synthesized test condition of the SCA.

For Katie, tangible and attention contingencies were evaluated in the isolated FAs and SCAs. Escape was excluded from the FA comparison for Katie because problem behavior was not reliably evoked by demands during either observation. To reduce problem behavior related to separation from her parents, Katie began her time at the clinic each day with an informal play condition during which she interacted freely with the experimenters in the session room while playing with preferred toys. This condition continued until she no longer engaged in loud vocalizations, crying, or other collateral problem behavior. This procedure became less necessary and was used less frequently after the first week. For Martin, tangible, attention, and escape contingencies were evaluated in the isolated FA and SCA. Finally, for Corey, tangible and escape contingencies were evaluated in the isolated FA and SCA. An evaluation of attention was excluded from the FA comparison for Corey because she did not engage in problem behavior in either observation when attention was restricted.

Isolated FA

Conditions were conducted similar to the procedures outlined by Iwata et al. (1982/1994). All sessions were 5 min.

Attention

Experimenters gave participants access to a moderately preferred leisure item throughout the session. Sessions began following 30 s of access to attention. The experimenter told the participant that they had some work to do and then moved away, restricting all attention. Contingent on the target problem behavior, the experimenter delivered attention for 30 s and then restricted it again. The form of attention was matched to that reported by and observed with caregivers in the open-ended interview and unstructured observation. Specifically, attention was delivered in the form of praise and comforting statements for Katie and in the form of vocal reprimands for Martin.

Tangible

Prior to the start of each session, the experimenter provided the participant 30 s of access to the most preferred leisure item based upon the results of the MSWO before removing the leisure item. Contingent on the target problem behavior, the experimenter delivered the leisure item for 30 s and then restricted it again. Leisure items included an iPad (Corey), an iPad and backpack (Katie), and an iPhone (Martin).

Escape

Demands included academic tasks (e.g., math worksheets, tracing, and sorting) for both Martin and Corey. When the session commenced, the experimenter delivered the demand using a least-to-most prompting sequence (verbal, model, and physical) with a 5-s interprompt interval. If the participant complied with the demand in the absence of physical guidance, the experimenter delivered brief praise (e.g., "Good job"). Contingent on the target problem behavior, the experimenter immediately terminated demands, and removed task materials for 30 s, before re-presenting the demand.

Control (Play)

The experimenter gave participants free and continuous access to the same item used in the

tangible condition and no demands were delivered. If attention was identified as a putative reinforcer, the experimenter delivered brief attention (e.g., "That toy looks fun") on a fixed-time 30-s schedule. The experimenter delayed delivery of attention by 5 s if the participant engaged in the target problem behavior. The experimenter responded to any mands for attention from the participant during the control condition, even if attention was not identified as a putative reinforcer. There were no differential consequences for problem behavior.

SCA

Synthesized (Test)

An experimenter gave participants 30 s of access to all putative reinforcers prior to each session. Following 30 s, all identified EOs were introduced and the session began. Contingent on the target problem behavior, the experimenter delivered all putative reinforcers in combination for 30 s. Katie's synthesized contingency included access to the iPad and backpack, and experimenter attention. The experimenter introduced the EO by restricting access to the iPad and backpack and withdrawing their attention. Contingent on Katie's problem behavior the experimenter provided the iPad and backpack, and access to their attention. Martin's synthesized contingency included escape from mathematics tasks as well as access to his iPhone and experimenter attention. The type of attention delivered for Katie and Martin was the same as delivered in the isolated FA, consisting of praise and comforting statements for Katie and vocal reprimands for Martin. Corey's synthesized contingency included escape from academic tasks and access to the iPad. The procedures during the SCA were the same as those in the isolated FA, including the introduction of EOs, demand delivery, and reinforcement. All sessions were 5 min.

Control (Play)

All putative reinforcers delivered in the test condition were freely and continuously available

during the control condition and no demands were delivered. If the synthesized contingency included attention, then the experimenter delivered brief attention (e.g., "That toy looks fun") on a fixed-time 30-s schedule. Experimenters delayed delivery of attention by 5 s if the target problem behavior occurred. The experimenter responded to any mands for attention emitted by the participant whether attention was included in the synthesized contingency or not. There were no programmed consequences for the target problem behavior. All sessions were 5 min.

Results

Observations

When Katie was observed interacting with her mother during the unstructured observation, problem behavior occurred only when access to leisure items was restricted. During Martin's interaction with his mother, he engaged in SIB when given instructions, although he often simultaneously complied with those instructions. He also engaged in high levels of SIB when his mother denied access to the iPad. During Corey's interaction with her mother, she screamed and cried when the iPad was taken away. She became aggressive when her mother attempted to interest her in other toys and when requests for the iPad were denied.

During the structured observation of Katie and an experimenter she did not engage in aggression. SIB occurred at variable rates across reinforcement opportunities but most consistently during attention trials. Loud vocalizations, specifically requests for her mother, initially occurred at high rates, and decreased during the course of the structured observation, suggesting that some of her problem behavior may have been related to separation from her mother rather than the programmed contingencies. Thus, the sequence of trials comprising the structured observation was conducted a second time with Katie, but with similar results.

During the structured observation of Martin and an experimenter SIB occurred in the majority of conditions involving demands and restricted attention, although moderate rates of SIB were observed inconsistently across all reinforcement opportunities. No aggression was observed during the structured observation. No aggression was observed during the structured observation of Corey and an experimenter. Collateral problem behavior such as screaming and disruption occurred during every reinforcement opportunity including escape and/or leisure items, except when attention was restricted in isolation.

Isolated FA and SCA

Figure 1 displays the results of the isolated FA and SCA for Katie (top panel), Martin (middle panel), and Corey (bottom panel). Results of the initial isolated phase conducted with Katie demonstrate differentiation between the control condition and both the tangible and attention conditions, although at lower levels and with less consistency for attention. Results of the initial synthesized phase for Katie show differentiation between the control condition and the combined tangible and attention test condition. Results of the initial phase were replicated upon the reintroduction of the isolated phase. Finally, the results of the SCA were replicated in the final phase. Although problem behavior was consistently high in the tangible condition, SIB occurred at variable levels in the attention condition. Given that (a) the purpose of the study was to evaluate the validity of the preliminary assessments, (b) the open-ended interview and structured observation both indicated that Katie's problem behavior was maintained by attention, and (c) the initial isolated FA results were unclear, we conducted an extended isolated attention contingency evaluation (see Figure 2 top panel). SIB initially occurred at high rates but decreased and did not occur after the third minute, suggesting

Figure 1
Problem Behavior per Minute

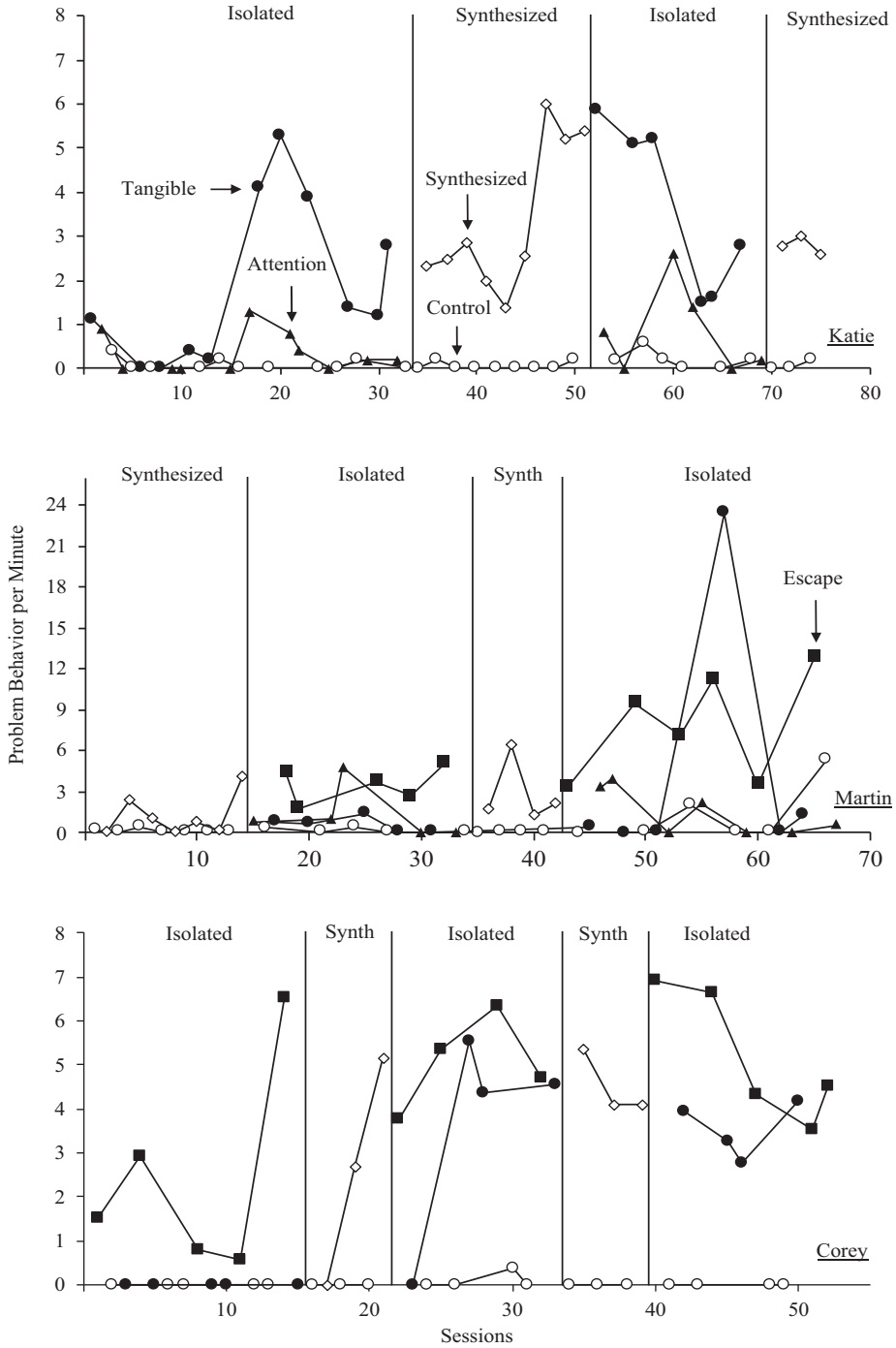
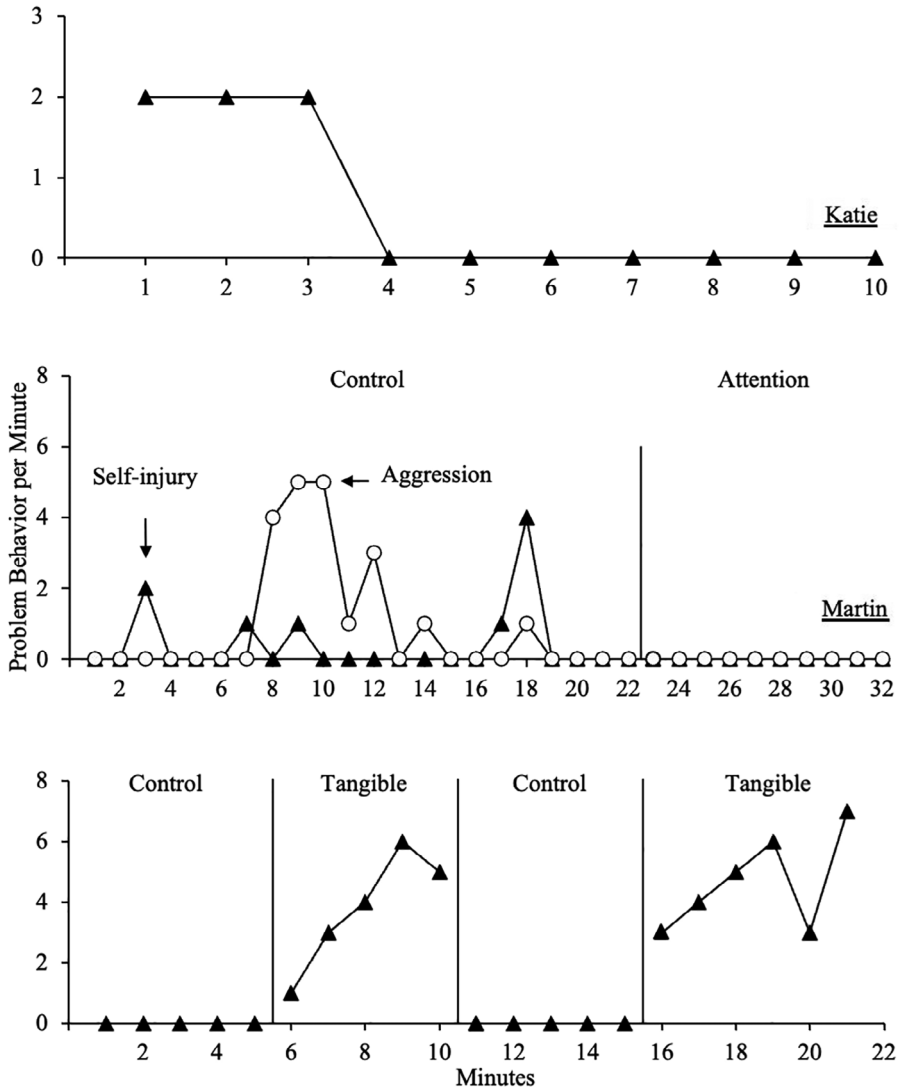


Figure 2
Problem Behavior per Minute During Extended Single-Condition Evaluations



that it may have occurred in the attention condition as carryover effects from the tangible condition in the multielement evaluation. Overall, the isolated FA identified a tangible function and ruled out attention, matching the results of the unstructured observation. Consistent with the results of the open-ended interview, the SCA produced differentiated rates of problem behavior in the control and test condition that included synthesized tangible and

attention contingencies. The results of neither the isolated FA nor the SCA fully matched those of the structured observation. Although attention was identified as a putative reinforcer by the structured observation and was included in the SCA, the tangible consequence was not.

For Martin, the initial synthesized phase demonstrated little-to-no differentiation between the test and control conditions. The introduction of the initial isolated FA phase

Table 1*Analyses Outcomes for Social Consequences*

Participant	Open-ended Interview	Unstructured Observation	Structured Observation	Isolated FA	SCA
Katie	Attention Tangible	Tangible	Attention	Tangible	Attention Tangible
Martin	Attention Tangible Escape	Tangible Escape	Attention Escape Tangible	Tangible Escape	Attention Escape Tangible
Corey	Tangible Escape Attention	Tangible Escape	Tangible Escape	Tangible* Escape	Tangible Escape

Note. False positives are indicated in bold typeface. Assessments are listed in the order in which they occurred; however, it should be noted that the order in which experimenters exposed participants to the isolated FA and SCA was counterbalanced across participants. Thus, the isolated FA did not always occur before the SCA. An asterisk denotes a functional stimulus that was not identified in the initial isolated phase but produced differentiated responding in the subsequent isolated phases (i.e., possible iatrogenic effect).

produced differentiation between the control condition and all three test conditions, but problem behavior ceased in the tangible and attention conditions and only persisted in the escape condition. In Martin's second synthesized phase, differentiation was observed between the control condition and the test condition. Variable rates of problem behavior were observed across all test conditions with the reintroduction of the final isolated phase, although there was clear and consistent differentiation between the control and escape conditions. As with Katie, lower and more variable levels of problem behavior were observed in the attention and tangible conditions, which had been identified as possible reinforcers in the preliminary assessments. Similar extended single conditions were conducted. Figure 2 (middle) displays the results for the extended isolated attention contingency evaluation, during which aggression and SIB decreased during a control condition and did not reemerge in a subsequent attention condition, ruling out attention as a reinforcer for Martin as well. Figure 2 (bottom) displays the results for the extended isolated tangible contingency evaluation, in which the rate of SIB was elevated in the tangible condition but did not occur in the control condition. This result indicates that SIB was maintained by access to preferred

tangible items. Overall, the isolated FA identified tangible and escape functions and ruled out attention. These results closely matched those of the unstructured observation. Conversely, only the second phase of the SCA produced differentiated rates of problem behavior between the control and test condition, matching the results of the open-ended interview and the structured observation.

Figure 1 (bottom) displays the results of the FA comparison for Corey. The initial isolated phase produced differentiation between the control and escape condition. Differentiation was also observed between the control and test condition upon introduction of the initial synthesized phase. When the isolated FA was reintroduced, differentiation was observed between the control condition and both the escape and tangible conditions. The results of the initial synthesized phase were replicated in the third phase. Finally, the isolated FA was introduced a third time and the results from the second isolated phase were replicated, in which differentiation was observed between the control condition and both the escape and tangible conditions. Overall, the isolated FA identified tangible and escape functions and the SCA produced differentiated rates of problem behavior when tangible and escape contingencies were combined. The results of both

analyses therefore matched the results of both the structured and unstructured observations. However, the finding that problem behavior served a tangible function as identified by the isolated FA should be interpreted with caution as it was not observed until after problem behavior had been exposed to the synthesized contingency, suggesting an iatrogenic effect (Retzlaff et al., 2020).

Table 1 summarizes the results of all four assessments for all participants. The reinforcers identified by caregivers in the open-ended interview did not match the results of the isolated FA for any participant but did match the results of the SCA for Katie and Martin. The results of the unstructured observation matched the results of the isolated FA for all three participants and matched the results of the SCA only for Corey. The results of the structured observation matched the results of the isolated FA only for Corey and matched the results of the SCA for Corey and Martin. Overall, the open-ended interview produced three false positives and five true positives across participants. The unstructured observation produced zero false positives and five true positives across participants. The structured observation and SCA each produced two false positives and four true positives across participants (five including the iatrogenic tangible consequence for Corey).

Discussion

The purpose of the current study was to compare the results of an isolated FA with those of an SCA when the stimuli selected for inclusion were based on both a structured and an unstructured observation. The results of the isolated FA and SCA comparison are consistent with previous research (e.g., Fisher et al., 2016; Greer et al., 2020; Holehan et al., 2020) in that problem behavior for all three participants was primarily maintained by one or more isolated contingencies. Although differentiation between test and control conditions occurred

more rapidly during the SCA, it also identified a false positive function for two of three participants and may have produced an iatrogenic tangible function for the third. These findings are inconsistent with the argument that the mixed findings in prior comparisons of the isolated FAs and SCAs may be due to differences in the sources of information that were used to select contingencies for inclusion in test conditions. Specifically, Fisher et al. (2016) and Greer et al. (2020) used an open-ended interview and a structured observation to inform the test conditions included in the SCA and found discrepant results between the isolated FA and the SCA. In the present study the structured observation better predicted the results of the SCA than did the unstructured observation that is typically used to inform SCAs.

In contrast to previous comparative studies, the test conditions in both analyses were informed by the open-ended interviews and two different observations. We adopted a conservative approach to selecting contingencies for inclusion in the isolated FA and SCA comparison by doing so if there was an indication from the open-ended interview and at least one of the observations that it functioned to maintain problem behavior. Even so, some of the contingencies that are typically included in the isolated FA (escape for Katie; attention for Corey) were eliminated by this process, and some contingencies that are more idiosyncratic, such as access to an iPad and a backpack with experimenter attention (Katie), were included. Thus, this approach could be a limitation of this study if it contributed to the identification of false positives. It is also possible that this method of selecting contingencies for inclusion could have produced false negative results (e.g., escape for Katie; attention for Corey), though no problem behavior was reliably observed during the unstructured observation, or the structured observations during which caregivers and experimenters, respectively, exposed participants to these putative

contingencies. Additionally, another potential limitation is that caregivers conducted the unstructured observation, whereas experimenters conducted the structured observation. It is possible that this approach could have led to differences in the way in which putative reinforcers were arranged and subsequently identified for inclusion in the isolated FA and SCA comparison.

One primary rationale that has been presented for using SCAs is the efficiency with which differentiation is obtained when only one test condition is being evaluated (e.g., Hanley et al., 2014; Jessel, Hanley et al., 2018). It is possible that limiting the test conditions in the isolated FA based on the results of an initial interview and observation may also increase its efficiency, but the results of the current study suggest that the SCA may still be more efficient. In an evaluation of efficiency across six different FA types, Saini et al. (2020) found that the SCA was more efficient than the isolated FA conducted using a multielement design in terms of overall time and number of sessions. The SCA and isolated FA were similarly efficient, however, when the authors compared the number of sessions required to identify one or more functions. Future research should continue to evaluate the efficiency of both analysis types and the degree to which differentiation may be obtained with shorter analyses. However, it should be emphasized that validity should not be compromised in the interest of efficiency.

Another topic for future research involves the possibility that SCAs may establish relationships between problem behavior and reinforcers (i.e., iatrogenic functions), rather than identifying preexisting functions. This has been a concern with isolated FAs as well (Rooker et al., 2011), although research suggests that introducing a single EO is unlikely to evoke problem behavior unless there is a prior history of reinforcement for a given stimulus (Lambert & Houchins-Juárez, 2020). In the

present study, a tangible function emerged in Corey's isolated FA only after exposure to the combined contingency in SCA. It is possible that repeated testing of the tangible condition in isolation contributed to this effect. However, given the fact that her caregiver suggested a potential tangible function in the open-ended interview, it may instead be the case that the initial isolated FA initially failed to detect a tangible function. Given the unreliability of caregiver report (Iwata et al., 2013; Kelley et al., 2011), this possibility seems less likely, but future researchers should evaluate the conditions under which isolated FAs are more or less likely to detect existing reinforcers versus establish new ones (e.g., extended exposure to EOs).

Finally, as alluded to above, there may be limitations to using the isolated FA as the gold standard for comparison. Another approach to comparing assessments involves analyzing their relative sensitivity, specificity, discriminant validity, and predictive validity. Tiger and Effertz (2020) used these concepts to compare the isolated FA and SCA and concluded that although both assessments are sensitive in that they are able to reliably identify reinforcing events, the SCA is not sufficiently specific because no such analyses in the extant literature have identified non-reinforcing events. The authors suggested that perhaps the SCA does not identify nonreinforcing events because those stimuli are ruled out by the open-ended interview with caregivers. This possibility raises the question of whether the SCA is then necessary to inform treatment or if the information gathered from the initial interview would be sufficient. The findings of the current study suggest that treatments based on the results of the open-ended interview would be the same as if they were based on the SCA for Katie and Martin, whereas treatment based on the open-ended interview for Corey would have included attention as an arbitrary contingency. A limitation of the current study is that a treatment

comparison was not included. Additional treatment research is necessary to evaluate the effectiveness of treatments based on an open-ended interview, as well as including arbitrary contingencies. Tiger and Effertz also suggested that the SCA is less specific because of its inability to distinguish between classes of reinforcement (i.e., discriminant validity). Specifically, observing differentiation during an SCA indicates a reinforcing effect, but it does not identify the specific event(s) contributing to the effect. Evaluating components of the synthesized contingency using an isolated FA would be necessary to identify the specific event(s) that evokes and maintains problem behavior (Tiger & Effertz, 2020). Indeed, evaluating components of the synthesized contingency individually in the isolated FA ruled out attention as a reinforcer for Katie and Martin in the current study.

To date, the outcomes of the four comparisons of isolated FAs and SCAs (Fisher et al., 2016; Greer et al., 2020; Holehan et al., 2020; Slaton et al., 2017) largely indicate that, for most individuals, problem behavior is primarily sensitive to the independent effects of isolated reinforcement contingencies. Additionally, the current findings suggest that using caregiver interviews to inform selection of contingencies in synthesized test conditions may contribute to the inclusion of arbitrary contingencies and lead to the identification of false positives. Practitioners should therefore take special care when informing selection of test conditions using the information reported by caregivers.

REFERENCES

- Beavers, G. A., Iwata, B. A., & Lerman, D. C. (2013). Thirty years of research on the functional analysis of problem behavior. *Journal of Applied Behavior Analysis, 46*(1), 1-21. <https://doi.org/10.1002/jaba.30>
- Bowman, L. G., Hardesty, S. L., & Mendres-Smith, A. (2013). A functional analysis of crying. *Journal of Applied Behavior Analysis, 46*(1), 317-321. <https://doi.org/10.1002/jaba.4>
- Bullock, C., Fisher, W., & Hagopian, L. (2017). Description and validation of a computerized behavioral data program: "BDataPro." *The Behavior Analyst, 40*(1), 275-285. <https://doi.org/10.1007/s40614-016-0079-0>
- Coffey, A. L., Shawler, L. A., Jessel, J., Nye M. L., Bain, T. A., & Dorsey, M. F. (2020). Interview-informed synthesized contingency analysis (IISCA): Novel interpretations and future directions. *Behavior Analysis in Practice, 13*(1), 217-225. <https://doi.org/10.1007/s40617-019-00348-3>
- Curtis, K. S., Forck, K. L., Boyle, M. A., Fudge, B. M., Speake, H. N., & Pauls, B. P. (2020). Evaluation of a trial-based interview-informed synthesized contingency analysis. *Journal of Applied Behavior Analysis, 53*(2), 635-648. <https://doi.org/10.1002/jaba.618>
- Day, R. M., Rea, J. A., Schussler, N. G., Larsen, S. E., & Johnson, W. L. (1988). A functionally based approach to the treatment of self-injurious behavior. *Behavior Modification, 12*(4), 565-589. <https://doi.org/10.1177/01454455880124005>
- DeLeon, I. G., & Iwata, B. A. (1996). Evaluation of a multiple-stimulus presentation format for assessing reinforcer preferences. *Journal of Applied Behavior Analysis, 29*(4), 519-533. <https://doi.org/10.1901/jaba.1996.29-519>
- Fisher, W. W., Greer, B. D., Romani, P. W., Zangrillo, A. N., & Owen, T. M. (2016). Comparisons of synthesized and individual reinforcement contingencies during functional analysis. *Journal of Applied Behavior Analysis, 49*(3), 596-616. <https://doi.org/10.1002/jaba.314>
- Ghaemmaghami, M., Hanley, G. P., Jin, S. C., & Vanselow, N. R. (2016). Affirming control by multiple reinforcers via progressive treatment analysis. *Behavioral Interventions, 31*(1), 70-86. <https://doi.org/10.1002/bin.1425>
- Greer, B. D., Mitteer, D. R., Briggs, A. M., Fisher, W. W., & Sodawasser, A. J. (2020). Comparisons of standardized and interview-informed synthesized contingencies relative to functional analysis. *Journal of Applied Behavior Analysis, 53*(1), 82-101. <https://doi.org/10.1002/jaba.601>
- Hagopian, L. P., Rooper, G. W., Jessel, J., & DeLeon, I. G. (2013). Initial functional analysis outcomes and modifications in pursuit of differentiation: A summary of 176 inpatient cases. *Journal of Applied Behavior Analysis, 46*(1), 88-100. <https://doi.org/10.1002/jaba.25>
- Hanley, G. P. (2012). Functional assessment of problem behavior: Dispelling myths, overcoming implementation obstacles, and developing new lore. *Behavior Analysis in Practice, 5*(1), 54-72. <https://doi.org/10.1007/BF03391818>
- Hanley, G. P., Iwata, B. A., & McCord, B. E. (2003). Functional analysis of problem behavior: A review. *Journal of Applied Behavior Analysis, 36*(2), 147-185. <https://doi.org/10.1901/jaba.2003.36-147>

- Hanley, G. P., Jin, C. S., Vanselow, N. R., & Hanratty, L. A. (2014). Producing meaningful improvements in problem behavior of children with autism via synthesized analyses and treatments. *Journal of Applied Behavior Analysis, 47*(1), 16-36. <https://doi.org/10.1002/jaba.106>
- Holehan, K. M., Dozier, C. L., Diaz de Villegas, S. C., Jess, R. L., Goddard, K. S., & Foley, E. A. (2020). A comparison of isolated and synthesized contingencies in functional analyses. *Journal of Applied Behavior Analysis, 53*(3), 1559-1578. <https://doi.org/10.1002/jaba.700>
- Iwata, B. A., DeLeon, I. G., & Roscoe, E. M. (2013). Reliability and validity of the Functional Analysis Screening Tool. *Journal of Applied Behavior Analysis, 46*(1), 271-284. <https://doi.org/10.1002/jaba.31>
- Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1994). Toward a functional analysis of self-injury. *Journal of Applied Behavior Analysis, 27*(2), 197-209. <https://doi.org/10.1901/jaba.1994.27-197> (Reprinted from "Toward a functional analysis of self-injury," 1982, *Analysis and Intervention in Developmental Disabilities, 2*(1), 3-20, 10.1016/0270-4684(82)90003-9)
- Jessel, J., Hanley, G. P., & Ghaemmaghani, M. (2016). Interview-informed synthesized contingency analyses: Thirty replications and reanalysis. *Journal of Applied Behavior Analysis, 49*, 576-595. <https://doi.org/10.1002/jaba.316>
- Jessel, J., Hanley, G. P., Ghaemmaghani, M., & Metras, R. (2018). An evaluation of the single-session interview-informed synthesized contingency analysis. *Behavioral Interventions, 34*(1), 62-78. <https://doi.org/10.1002/bin.1650>
- Jessel, J., Ingvarsson, E. T., Metras, R., Whipple, R., Kirk, H., & Solsbery, L. (2018). Treatment of elopement following a latency-based interview-informed, synthesized contingency analysis. *Behavioral Interventions, 33*(3), 271-283. <https://doi.org/10.1002/bin.1525>
- Kelley, M. E., LaRue, R. H., Roane, H. S., & Gadaire, D. M. (2011). Indirect behavioral assessments: Interviews and rating scales. In W. W. Fisher, C. C. Piazza, & H. S. Roane (Eds.), *Handbook of applied behavior analysis* (pp. 182-190). Guilford.
- Lambert, J. M., & Houchins-Juárez, N. J. (2020). Do functional analyses probe learning histories, or create them? An exploratory investigation. *American Journal on Intellectual and Developmental Disabilities, 125*(3), 200-216. <https://doi.org/10.1352/1944-7558-125.3.200>
- Mace, F. C., & West, B. J. (1986). Analysis of demand conditions associated with reluctant speech. *Journal of Behavior Therapy and Experimental Psychiatry, 17*(4), 285-294. [https://doi.org/10.1016/0005-7916\(86\)90065-0](https://doi.org/10.1016/0005-7916(86)90065-0)
- Querim, A., Iwata, B., Roscoe, E., Schlichenmeyer, K., Virués Ortega, J., & Hurl, K. (2013). Functional analysis screening for problem behavior maintained by automatic reinforcement. *Journal of Applied Behavior Analysis, 46*(1), 47-60. <https://doi.org/10.1002/jaba.26>
- Retzlaff, B. J., Fisher, W. W., Akers, J. S., & Greer, B. D. (2020). A translational evaluation of potential iatrogenic effects of single and combined contingencies during functional analysis. *Journal of Applied Behavior Analysis, 53*(1), 67-81. <https://doi.org/10.1002/jaba.595>
- Rooker, G. W., Iwata, B. A., Harper, J. M., Fahmie, T. A., & Camp, E. M. (2011). False-positive tangible outcomes of functional analyses. *Journal of Applied Behavior Analysis, 44*(4), 737-745. <https://doi.org/10.1901/jaba.2011.44-737>
- Roscoe, E. M., Schlichenmeyer, K. J., & Dube, W. V. (2015). Functional analysis of problem behavior: A systematic approach for identifying idiosyncratic variables. *Journal of Applied Behavior Analysis, 48*(2), 289-314. <https://doi.org/10.1002/jaba.201>
- Saini, V., Fisher, W. W., Retzlaff, B. J., & Keevy, M. (2020). Efficiency in functional analysis of problem behavior: A quantitative and qualitative review. *Journal of Applied Behavior Analysis, 53*(1), 44-66. <https://doi.org/10.1002/jaba.583>
- Slaton, J. D., & Hanley, G. P. (2018). Nature and scope of synthesis in functional analysis and treatment of problem behavior. *Journal of Applied Behavior Analysis, 51*(4), 943-973. <https://doi.org/10.1002/jaba.498>
- Slaton, J. D., Hanley, G. P., & Raftery, K. J. (2017). Interview-informed functional analyses: A comparison of synthesized and isolated components. *Journal of Applied Behavior Analysis, 50*(2), 252-277. <https://doi.org/10.1002/jaba.384>
- Tiger, J. H., & Effertz, H. M. (2020). On the validity of data produced by isolated and synthesized contingencies during the functional analysis of problem behavior. *Journal of Applied Behavior Analysis, 54*(3), 853-876. <https://doi.org/10.1002/jaba.792>

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