Toward accurate inferences of response class membership

CHRISTINE A. WARNER
WESTERN NEW ENGLAND UNIVERSITY AND NEW ENGLAND CENTER FOR CHILDREN

GREGORY P. HANLEY, ROBIN K. LANDA, KELSEY W. RUPPEL, ADITHYAN RAJARAMAN AND MAHSHID GHAEMMAGHAMI
WESTERN NEW ENGLAND UNIVERSITY

JESSICA D. SLATON
WESTERN NEW ENGLAND UNIVERSITY AND NASHOBA LEARNING GROUP

HOLLY C. GOVER
WESTERN NEW ENGLAND UNIVERSITY

In their review of synthesis within the functional analysis (FA) literature, Slaton and Hanley (2018) reported that most synthesized contingency analyses have included multiple topographies of problem behavior in the reinforcement contingency class. This leaves the question of whether one, some, or all forms of problem behavior are sensitive to the synthesized reinforcement contingencies in published analyses. To address this ambiguity, all topographies of problem behavior that were reported by caregivers to co-occur with the most concerning problem behavior were analyzed for 10 participants. We implemented extinction across one or more forms of problem behavior to determine whether all forms reported to co-occur were sensitive to the same synthesized reinforcement contingency. For nine of 10 participants, the most concerning topographies were sensitive to the same synthesized reinforcement contingencies as the less concerning topographies (results were inconclusive for one). Implications for inferring response class membership from single analyses are discussed.

Key words: consecutive controlled case series, extinction, functional analysis, precursors, problem behavior, response classes

The prevalence of problem behavior such as aggression, self-injurious behavior (SIB), and destructive behavior in individuals with intellectual disabilities ranges from 10 to 52% (Dworschak, Ratz, & Wagner, 2016; Emerson et al., 2001; Holden & Gitlesen, 2003). Murphy, Healy, and Leader (2009) found that 64% of children with autism exhibited aggression, SIB, or both. Furthermore, individuals with intellectual disabilities (Emerson & Bromley, 1995) and autism (Murphy et al., 2009) often display multiple forms of problem behavior including aggression, SIB, disruption, destruction, tantrum, noncompliance, screaming, and stereotypy.

If multiple responses have the same effect on the environment, they are considered members of a response class (Catania, 2007). By extension, members of a response class are also likely to be evoked by the same establishing operations (EOs). The concept of a class of topographically dissimilar behaviors reinforced by similar consequent events and evoked by similar EOs has important implications for treatment,
because a single treatment can be implemented and should be effective for all members of a response class. Therefore, when attempting to address severe problem behavior, it is important to understand which topographies share the same controlling reinforcement contingency.

In a review of research relevant to functional analyses (FAs) of problem behavior, Hanley, Iwata, and McCord (2003) recommended that a single topography of problem behavior be targeted in an FA to ensure an efficacious treatment is developed for each topography of problem behavior. When multiple topographies are included in the reinforcement contingency and only one or some topographies show sensitivity during the FA, one may make an incorrect inference that the variables controlling the topographies that showed sensitivity are the same variables that are controlling the topographies not observed in the analysis. If these inferences are wrong, the treatment will be only partially effective; if response topographies are analyzed in aggregate, the treatment will show only marginal effects or, if response topographies are measured separately (Derby et al., 1994), only some topographies will be affected by treatment while others will either show no change or may worsen.

The results of Iwata, Pace, Cowdery, and Miltenberger (1994) partly illustrated these effects when they showed that extinction procedures mismatched to function had no effect on problem behavior. In addition, Iwata et al. (1994) noted the possibility that certain irrelevant extinction procedures may be contraindicated for certain functions. Furthermore, Thompson, Fisher, Piazza, and Kuhn (1998) identified two different functions for different topographical sets of aggression and subsequently showed that distinct treatments were required for each topographical set.

The general necessity of separately analyzing each topography of problem behavior is, however, not strongly supported. Thompson et al. (1998) is the only study showing the benefits of possibly doing so, and it should be noted that the authors were able to glean the different controlling variables in the initial FA in which all topographies were included. In addition, functionally analyzing each topography of problem behavior probably requires a prohibitive amount of time and resources for most behavior analysts, who most often report not conducting any FAs of problem behavior (Oliver, Pratt, & Normand, 2015; Roscoe, Phillips, Kelly, Farber, & Dube, 2015).

The alternative to conducting separate FAs for each topography of problem behavior is to program putative reinforcers for multiple topographies of problem behavior in a single FA (e.g., Hagopian, Bruzek, Bowman, & Jennett, 2007; Hanley, Jin, Vanselow, & Hanratty, 2014; Lalli, Mace, Wohn, & Livezey, 1995; Mace, Page, Ivancic, & O’Brien, 1986; Magee & Ellis, 2000; Slaton, Hanley, & Raftery, 2017). Including multiple topographies in single analyses has been fairly common practice in recent years. A review of FAs by Beavers, Iwata, and Lerman (2013) found that 76% of reviewed FA studies included multiple topographies of problem behavior. Focusing on analyses in which two or more reinforcing contingencies were arranged in a single test condition, Slaton and Hanley (2018) reported that 81% of synthesized contingency analyses included multiple topographies of problem behavior. Researchers have used multiple ways to communicate the differences of including one or a few versus many topographies of problem behavior in the contingency class in a FA: single versus multiple response topographies (Beavers & Iwata, 2011), dangerous problem behavior versus dangerous and nondangerous problem behavior (Jessel, Hanley, & Ghaemmaghami, in press), and isolated contingency class versus synthesized contingency class (Slaton & Hanley, 2018). \[^{1}\] In an

\[^{1}\]Throughout the paper, the terms open- and closed-contingency class indicate the responses available for reinforcement during the functional analysis. These terms are to be distinguished from open and closed economies which refer to operant contexts in which appetitive stimuli are
attempt to depict the continuum on which response topographies are synthesized, we will use the term *open-contingency class* to refer to instances in which all co-occurring topographies were available for reinforcement and *relatively closed-contingency class* to refer to instances in which one to several topographies were available for reinforcement during the FA.

When researchers have, for various reasons and with various methods, analyzed whether multiple topographies of problem behavior described by caregivers are members of the same response class, the answer is overwhelmingly yes (Borlase, Vladescu, Kisamore, Reeve, & Fetzer, 2017; Borrero & Borrero, 2008; DeRosa, Roane, Doyle, & McCarthy, 2013; Fritz, Iwata, Hammond, & Bloom, 2013; Harding et al., 2001; Herscovitch, Roscoe, Libby, Bourret, & Ahearn, 2009; Lalli et al., 1995; Langdon, Carr, & Owen-DeSchryver, 2008; Lieving, Hagopian, Long, & O’Connor, 2004; Magee & Ellis, 2000; Richman, Wacker, Asmus, Casey, & Andelman, 1999; Smith & Churchill, 2002). For example, several studies have functionally analyzed precursors to problem behavior and results showed that precursors (i.e., behaviors reported to precede severe problem behavior) were members of the same response class as the more severe forms of problem behavior (Borlase et al., 2017; Borrero & Borrero, 2008; Fritz et al., 2013; Herscovitch et al., 2009; Langdon et al., 2008; Smith & Churchill, 2002). Similar outcomes are evident across several studies that applied extinction to analyze potential response class hierarchies; they each found that all topographies of problem behavior were members of the same response class (DeRosa et al., 2013; Harding et al., 2001; Lalli et al., 1995; Lieving, et al., 2004; Richman et al., 1999). Relying on procedures from Lalli et al. (1995), Magee and Ellis (2000) initially implemented FAs with two participants with a relatively open-contingency class, and progressively closed the contingency class until extinction was applied to and achieved with all topographies of problem behavior. For both participants, all target behaviors appeared to be sensitive to the same reinforcement contingency as new topographies were evoked when extinction was applied to the forms of behavior evincing the highest rate.

All studies that have evaluated response class membership have included isolated reinforcement contingencies. Considering that hundreds of synthesized contingency analyses have been published (Jessel, Ingvarsson, Metras, Kirk, & Whipple, 2018; Slaton & Hanley, 2018) and these analyses usually arrange for reinforcement for multiple topographies of problem behavior, it seems important to evaluate response class membership following analyses relying on synthesized reinforcement contingencies. The method we used in the current study to make inferences regarding response class membership in synthesized contingency analyses was largely based on the procedures of Magee and Ellis (2000) in that procedural extinction was progressively applied to evaluate whether problem behaviors reported to co-occur were sensitive to the same reinforcement contingency. We evaluated the effects of relatively open- and closed-contingency classes on rates of individual topographies and total problem behavior in 10 consecutively enrolled study participants, all children who were reported to engage in multiple topographies of problem behavior. Results are reported for all children who experienced some form of contingency class manipulation. Therefore, the study conforms to a consecutive controlled case series design (CCCSD; Hagopian, Rooker, Jessel, & DeLeon, 2013; Jessel et al., 2018; Slaton et al., 2017). These

---

2Throughout the paper, *co-occurring behavior* refers to topographies of problem behavior and precursor behavior that were reported to occur in the same time and context.
methods circumvent the file drawer problem (Rosenthal, 1979; Scargle, 2000) that is inevitable in research relying on single-subject experimental designs in which positive results (i.e., functional relations) are published and negative results are not. The generality of functional relations between independent and dependent variables can be established via systematic replications (Sidman, 1960), but due to the inevitable publication bias toward positive outcomes, the probability that demonstrated relations will hold under different conditions is unclear, even when many systematic replications are published. By incorporating a CCCSD into this study, results will be less affected by this traditional bias and may instead convey both the possibility and probability of the demonstrated functional relations. In particular, the probability that multiple topographies of problem behavior that are reported to co-occur are sensitive to the same synthesized reinforcement contingency may be revealed in this study.

METHODS

Participants
Participants were consecutively enrolled in the study across three sites (see Table 1 for participant characteristics). Participants would have been excluded if (i) caregivers reported only one topography of problem behavior, (ii) all reported topographies were observed and reinforced in the initial Interview-informed synthesized contingency analysis (IISCA) (Hanley et al., 2014; Jessel, Hanley, & Ghaemmaghami, 2016; Jessel et al., 2018), or (iii) guardian consent and participant assent for the process was not obtained. No subject was excluded based on any of these criteria. Participants included 10 children who engaged in multiple topographies of problem behavior that were reported by caregivers to co-occur. The participants included two females and eight males between the ages of 3 and 18 years. Six were diagnosed with autism, one was diagnosed with autism and attention-deficit hyperactivity disorder, one was diagnosed with hydrocephalus, conduct disorder, and destructive behavior disorder, and two participants did not have any formal diagnoses. All participants engaged in at least one topography of severe problem behavior, most engaged in multiple forms, and most were reported to also engage in some less dangerous forms of problem behavior.

Settings and Personnel
Sessions were conducted in three settings. Sessions with Cole, Raj, Ali, and Caleb were conducted in session rooms that ranged between 3 m × 3 m to 3.5 m × 4 m at a specialized school for children with autism. Sessions with Bill were conducted at a different specialized school for children with autism. Sessions with Milly, Luke, Jordan, Annie, and Mike were conducted in a 4 m × 3 m session room at a university outpatient clinic. Across all locations, session rooms were equipped with video recording equipment, a table and one or two chairs, and participant-specific materials (e.g., toys, activities, electronics, teaching materials).

Two analysts were Board Certified Behavior Analyst Doctorates (BCBA-D), four were Board Certified Behavior Analysts (BCBAs), and one was enrolled in behavior analytic coursework to complete BCBA certification requirements at the time of the study. All analysts had conducted IISCA prior to this study. Supervision was provided by the second author who was a BCBA-D and experienced in conducting FAs.

Response Measurement
Responses were scored using a laptop computer with a data collection and analysis program. For each participant, the duration of each reinforcement interval and the frequency of each topography of problem behavior were

---

3Caregiver interview information and functional analysis data for Milly and Luke were previously published in Ghaemmaghami, Hanley, Jessel, and Landa (2018).
scored. Response topographies for each participant are shown in Table 2 and are defined individually for each participant. Specific response definitions are available upon request.

Table 1
Participant Characteristics

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Sex</th>
<th>Program type</th>
<th>Diagnosis</th>
<th>Communication Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cole</td>
<td>8</td>
<td>M</td>
<td>Day program at specialized school</td>
<td>Autism</td>
<td>Full sentences</td>
</tr>
<tr>
<td>Raj</td>
<td>5</td>
<td>M</td>
<td>Day program at specialized school</td>
<td>Autism</td>
<td>Vocal approximations, signs, and SGD</td>
</tr>
<tr>
<td>Milly</td>
<td>10</td>
<td>F</td>
<td>University-based outpatient clinic</td>
<td>Autism</td>
<td>Nonvocal, gestures, a few phrases</td>
</tr>
<tr>
<td>Bill</td>
<td>15</td>
<td>M</td>
<td>Day program at specialized school</td>
<td>Autism</td>
<td>Short, disfluent sentences</td>
</tr>
<tr>
<td>Caleb</td>
<td>18</td>
<td>M</td>
<td>Residential program at specialized school</td>
<td>Autism</td>
<td>Vocal approximations, gestures, and SGD</td>
</tr>
<tr>
<td>Ali</td>
<td>12</td>
<td>M</td>
<td>Day program at specialized school</td>
<td>Autism</td>
<td>Signs and gestures</td>
</tr>
<tr>
<td>Luke</td>
<td>5</td>
<td>M</td>
<td>University-based outpatient clinic</td>
<td>Autism and ADHD</td>
<td>Full sentences</td>
</tr>
<tr>
<td>Jordan</td>
<td>3</td>
<td>M</td>
<td>University-based outpatient clinic</td>
<td>None</td>
<td>Full sentences</td>
</tr>
<tr>
<td>Annie</td>
<td>4</td>
<td>F</td>
<td>University-based outpatient clinic</td>
<td>Hydrocephalus, conduct disorder, destructive behavior disorder</td>
<td>Short, disfluent sentences</td>
</tr>
<tr>
<td>Mike</td>
<td>4</td>
<td>M</td>
<td>University-based outpatient clinic</td>
<td>None</td>
<td>Full sentences</td>
</tr>
</tbody>
</table>

Note. ADHD = attention deficit hyperactivity disorder; SGD = speech generating device.

Table 2
Topographies of Problem Behavior

<table>
<thead>
<tr>
<th>Participant</th>
<th>Problem behaviors reported to co-occur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cole</td>
<td>Aggression*, disruption, disruptive vocalizations (screaming, name calling, threatening, swearing), SIB, whining</td>
</tr>
<tr>
<td>Raj</td>
<td>Aggression, disruption, face and ear covering, flopping, SIB*, stomping</td>
</tr>
<tr>
<td>Milly</td>
<td>Aggression, chin-grinding, disruptive vocalizations (screaming and yelling), flopping, SIB, swiping items</td>
</tr>
<tr>
<td>Bill</td>
<td>Complaining, disruption*</td>
</tr>
<tr>
<td>Caleb</td>
<td>Aggression, bolting, face covering, screaming, SIB*</td>
</tr>
<tr>
<td>Ali</td>
<td>Aggression*, body SIB, disruption, head SIB</td>
</tr>
<tr>
<td>Luke</td>
<td>Aggression, disruption, disruptive sounds (signing, hissing, growling), disruptive vocalizations (screaming or yelling), throwing</td>
</tr>
<tr>
<td>Jordan</td>
<td>Aggression*, disruption, disruptive vocalizations (screaming and yelling), throwing items</td>
</tr>
<tr>
<td>Annie</td>
<td>Disruption, disruptive vocalizations (screaming, yelling, swearing), hitting and pushing, scratching, throwing items</td>
</tr>
<tr>
<td>Mike</td>
<td>Aggression*, disruption, disruptive vocalizations (screaming and yelling), flopping, vocal protests (whining or complaining)</td>
</tr>
</tbody>
</table>

Note. Problem behaviors are listed in alphabetical order. SIB = self-injurious behavior. The asterisk indicates the most concerning topography of problem behavior for each participant as indicated by the caregiver interview.

The reinforcement interval began when putative reinforcers were delivered to the participant and ended when those reinforcers were removed. Session counts of problem behavior were converted into a session rate for all analyses. The duration of emotional responding (defined as crying or wailing), which was scored for Raj, Jordan, and Mike, was converted into percentage of session by dividing the duration of the response by the total session duration.

Interobserver Agreement
A second observer independently scored at least 20% of sessions across participants in each condition of the analysis for each participant (range: 20–66%) to evaluate interobserver agreement (IOA). 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 across participants was 97% (session range: 77–100%).

Experimental Designs
A multielement design was used to compare rates of problem behavior in the test and control condition during the analysis. A multiple
baseline design across topographies and reversal design were used during the extinction analyses. Experimental control of a topography of problem behavior was demonstrated by a change in the level of responding when other members of the contingency class were added or removed.

**Participant Protections**

Several measures were taken to protect the participants. All procedures were reviewed by an Institutional Review Board. Prior to conducting any analysis, conservative session termination criteria were determined by the lead author and the supervising clinician of all children who participated in the school. These termination criteria were never met. At least one caregiver was present for all sessions conducted in the outpatient clinic and at least one teacher was present for all sessions conducted in the school. The caregiver or teacher was informed that they could terminate the analysis at any point if they were uncomfortable with proceeding for any reason. Analysts and data collectors were provided with the same authority.

**Caregiver Interview and FA**

An open-ended interview was conducted with one or two caregivers to identify potential variables contributing to the maintenance of problem behavior. The interview questions were the same as those in the appendix of Hanley (2012) and additional questions were asked for clarification as necessary. The open-ended interview lasted 30–45 min and included questions about the participant’s interests, language abilities, situations in which problem behavior occurred, and ways in which caregivers responded to the child’s problem behavior. The interview included questions to determine the specific forms of problem behavior, which topographies of problem behaviors were considered a priority for treatment, which tended to cluster together, and whether the child emitted any precursors to the more dangerous forms.

The interview also included a question to determine whether any of the reported co-occurring forms were suspected to be a form of self-stimulation. If a potentially automatically maintained form of behavior was reported (e.g., stereotypic vocalizations), this form was not included in the analysis. A brief observation which lasted 15 min was also conducted for the children served at the school during which the analyst observed the child’s interactions with people and materials and ways in which the teachers interacted with the child.

An IISCA was conducted with each participant. Information about the child’s problem behavior from the interview (and observation for some), informed the design of distinct FAs for each child (see Table 3 for the general and specific synthesized contingencies evaluated for each participant). All reported topographies of problem behavior were measured throughout each analysis and reinforced in the test sessions of the analysis. Sessions alternated between a single test and control condition. In the control condition, which was conducted first, all putative reinforcers were available continuously and noncontingently throughout the session. In any analysis in which adult compliance with mands was a putative reinforcer, mands were honored on a continuous reinforcement schedule. In the test condition, all putative reinforcers were removed simultaneously; contingent on any instance of problem behavior, all putative reinforcers were simultaneously delivered for 30 s. Sessions had a duration of 5 min for each participant, except Bill whose sessions were 3 min due to efficient responding in the analysis and Caleb whose sessions were 10 min due to initial low rates of responding. Additional information on how analyses were designed from interviews is available Appendix S1.

**Extinction Analyses**

After the initial FA, an extinction analysis was conducted during which extinction
procedures were progressively applied to the highest probability topographies of problem behavior observed during the IISCA while all other topographies remained available for reinforcement. Three versions of the extinction analysis were conducted. During the progressive extinction analysis (Cole, Raj, Milly, Bill, Caleb), the analyst applied extinction procedures to the most probable topography of problem behavior from the IISCA and continued the test sessions until another topography emerged and persisted for at least two consecutive sessions. Extinction procedures were then applied to the topography that emerged, in addition to the topography that was previously placed on extinction. This process continued until either all reported topographies of problem behavior emerged and persisted, or four sessions occurred without the emergence of any reported topographies of problem behavior. During the expedited extinction analysis (Ali, Luke, Jordan, Annie), extinction procedures were applied to all topographies of problem behavior following the initial analysis, and only the most concerning topography of problem behavior was reinforced. The relatively closed-contingency class continued until the most concerning form of problem behavior emerged and persisted or four sessions occurred without the emergence of the most concerning form of problem behavior (this did not occur for any participant). The procedures for the brief extinction analysis (Mike) were identical to the expedited extinction analysis, except that all topographies of problem behavior were placed on extinction and only the most concerning topography was reinforced for a single session. Across all three versions of the extinction analysis, the contingency was reopened such that all topographies of problem behavior were reinforced in the final phase (as they had been in the initial analysis). Although the procedures are described as extinction analyses, it is important to note that the focus was on the emergence of other topographies of problem behavior as procedural extinction was applied.

### Table 3

<table>
<thead>
<tr>
<th>Participant</th>
<th>General contingency</th>
<th>Specific contingency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cole</td>
<td>Escape to tangibles and mand compliance</td>
<td>Escape from adult instruction to engage in math, reading, writing, and problem-solving tasks to iPad and toys, and compliance with mands (e.g., to change positions, color in specific ways, or watch videos together)</td>
</tr>
<tr>
<td>Raj</td>
<td>Escape to tangibles, attention, and mand compliance</td>
<td>Escape from adult instruction to engage in sorting, identifying attributes, and stretching tasks to toys, attention (hugs, tickles, making faces), and compliance with mands to play in specific ways</td>
</tr>
<tr>
<td>Milly</td>
<td>Access to tangibles and mand compliance</td>
<td>Access to tablets, playdoh, soft toys, and mand compliance</td>
</tr>
<tr>
<td>Bill</td>
<td>Escape to tangibles, attention, and stereotypy</td>
<td>Escape from vocational tasks to figurines, conversation about preferred topics, and stereotypy</td>
</tr>
<tr>
<td>Caleb</td>
<td>Escape to tangibles and attention</td>
<td>Escape from interruption of ongoing activity by adult instructions to iPad, puzzles, and books, and attention (conversation, praise, head rubs)</td>
</tr>
<tr>
<td>Ali</td>
<td>Escape to mand compliance</td>
<td>Escape from life skills tasks (brushing hair and teeth) to compliance with mands for walks, ribbons, and snacks</td>
</tr>
<tr>
<td>Annie</td>
<td>Access to tangibles, attention, and mand compliance</td>
<td>Access to tangibles, attention from analyst and Grandma, and mand compliance to play</td>
</tr>
<tr>
<td>Luke</td>
<td>Escape to tangibles, attention, and mand compliance</td>
<td>Escape from adult instruction to tangibles, attention, and mand compliance to play in specific ways</td>
</tr>
<tr>
<td>Jordan</td>
<td>Escape to tangibles, attention, and mand compliance</td>
<td>Escape from adult instruction (put on coat, play with different toys, clean up) to toys, attention, and mand compliance to provide specific forms of attention</td>
</tr>
<tr>
<td>Mike</td>
<td>Escape to tangibles and attention</td>
<td>Escape from cleaning up toys to Legos and action figures and attention</td>
</tr>
</tbody>
</table>
across topographies, as opposed to achieving extinction of any particular response form. Concerns for participant and analyst safety and efficiency were factors in this decision.

Contingency Strength Analysis

To determine whether the persistence of Cole’s inappropriate vocalizations during the extinction procedures was due to the responses placed on extinction adventitiously co-occurring with reinforcement deliveries for other responses, contingency strength values were calculated for Cole’s disruptive vocalizations based on the procedures by Luczynski and Hanley (2009). The measure of contingency strength included two relations between target responses placed on extinction and reinforcement delivery. A response conditional probability was calculated as the number of times the target response occurred within 10 s of reinforcement delivery, divided by the total number of target responses. An event conditional probability was also calculated by measuring the number of times reinforcement deliveries were not preceded by the target response within 10 s, divided by the total number of reinforcement deliveries. The event conditional probability was subtracted from the response conditional probability, producing a value of contingency strength between −1 and 1. The response conditional probability and event conditional probability for the target response were calculated for each session during the application of extinction only.

RESULTS

Differential responding between the test and control condition in the FA was obtained for all participants (see Figure 1). For four of the five participants for whom the progressive extinction analysis was conducted, topographies of problem behavior reported to co-occur in the caregiver interview appeared to be evoked and maintained by the same contingencies (see Figures 2–5).

The progressive extinction analysis for Bill showed that complaining and disruption were evoked and maintained by the same synthesized contingency (Figure 5). Although aggression was not reported in the interview and was not reinforced, aggression emerged when complaining was placed on extinction, and returned to zero in the third phase. It is unclear whether aggression was induced by the application of extinction of a previously reinforced response (complaining) or we observed the resurgence of aggression.

The results of Caleb’s extinction analysis were ambiguous (Figure 6). For Caleb, screaming, which was observed at the highest rate during the IISCA, decreased to zero during the extinction analysis and no other forms of problem emerged, therefore we were unable to determine whether the less-concerning topographies of problem behavior were members of the same response class as the most concerning topographies (aggression and SIB). The results suggest that either (i) extinction occurred and had a generalized effect or (ii) the responses reported to co-occur were not in the same response class as screaming (for Caleb only). One might expect that if the responses were not in the same response class, screaming would have occurred again in the third phase when it was scheduled for reinforcement. The fact that screaming remained at or near zero when it was available for reinforcement provides some evidence that extinction occurred; however, without further investigation, Caleb’s results are difficult to interpret.

For all participants for whom an expedited extinction analysis was conducted (Figures 7–9), the most concerning topography was evoked and maintained by the same contingencies as the topography or topographies observed during the analysis. For Mike (Figure 10), who participated in the brief extinction analysis, the most concerning topography appeared to be
Figure 1. IISCAs across the 10 consecutive participants.
Figure 2. Progressive extinction analysis data for Cole. The top three most concerning behaviors are indicated by the numbers 1–3 on the y-axis labels, with 1 being the most concerning topography. SIB = self-injurious behavior.

Figure 3. Progressive extinction analysis for Raj. The top three most concerning behaviors are indicated by the numbers 1–3 on the y-axis labels, with 1 being the most concerning topography. SIB = self-injurious behavior.
evoked and maintained by the same contingencies as the topography observed during the FA. Within-session data depictions were used to resolve some interpretive ambiguity. For instance, Cole’s extinction analysis shows an initial increase in whining, disruption, and aggression each time a new topography was placed on extinction, followed by a decrease in those responses. Disruptive vocalizations, however, persisted despite no longer being programmed for reinforcement. To evaluate why disruptive

Figure 4. Progressive extinction analysis for Milly. The top three most concerning behaviors are indicated by the numbers 1–3 on the y-axis labels, with 1 being the most concerning topography.

Figure 5. Progressive extinction analysis for Bill. The most concerning behaviors are indicated by the numbers on the y-axis labels, with 1 being the most concerning topography (aggression was not ranked because it was not reported in the interview).
Figure 6. Progressive extinction analysis for Caleb. The most concerning topography of problem behavior is indicated by the number 1. SIB = self-injurious behavior.

Figure 7. Expedited extinction analysis for Ali. The two most concerning behaviors are indicated by the numbers on the y-axis labels, with 1 being the most concerning topography. SIB = self-injurious behavior.
Figure 8. Expedited extinction analyses for Luke and Jordan. The most concerning topography of problem behavior for each participant is indicated by the number 1.
Figure 9. Expedited extinction analysis for Annie. The most concerning topography of problem behavior is indicated by the number 1.

Figure 10. Expedited extinction analysis for Mike. The most concerning topography of problem behavior is indicated by the number 1.
vocalizations persisted under extinction, we conducted a second-by-second analysis (based on the within-session analysis described by Stocco, Thompson, & Rodriguez, 2011) across all sessions in which extinction was applied to disruptive vocalizations. Figures 11 and 12 show that although reinforcement was not programmed for disruptive vocalizations in sessions 10–19, reinforcement was contiguous with these responses. Figures 11 and 12 also depict that disruptive vocalizations were evoked immediately following reinforcement withdrawal and did not occur during reinforcement. In addition, we conducted a contingency strength analysis for all sessions in which extinction was applied to disruptive vocalizations. An increasing contingency strength across extinction phases is evident. Collectively, these results support the notion that disruptive vocalizations were maintained by the same reinforcement contingency as that influencing SIB and aggression, even though disruptive vocalizations did not extinguish when the programed reinforcement was discontinued.

Because we placed all of Mike’s responses except for aggression on extinction for a single session only (Figure 13), it was unclear whether aggression was controlled by the synthesized contingency or was induced by extinction. To address this question, we conducted a second-by-second analysis for aggression and disruptive vocalizations (the topography observed at the highest rate when the contingency class was open) for sessions 3–5. Figure 13 shows that
Figure 12. Second-by-second within-session data for Cole depicting SIB, aggression, disruptive vocalizations (Disr vocs), and reinforcement intervals when reinforcement was programmed for only self-injurious behavior (SIB). The contingency strength values for disruptive vocalizations are noted by CS values for each session. The question being addressed here is why disruptive vocalizations persisted when placed on extinction in sessions 13–19 for Cole on Figure 2.
Aggression did not occur in sessions 3 and 5 when all responses were available for reinforcement in sessions 3 and 5. During session 4, aggression was evoked following reinforcement withdrawal and did not occur during reinforcement. The results of the within-session analysis and the fact that Mike’s parents reported aggression to co-occur with the other responses, support the notion that aggression was maintained by the same reinforcement contingency as that influencing Mike’s less-concerning topographies.

The question being addressed in Figure 14 is whether open- and closed-contingency classes affect total problem behavior and emotional responding. Figure 14 displays total problem behavior across sessions for all 10 participants. Breaks in the data path within a phase (see panels for Milly, Cole, and Raj) indicate the point at which extinction procedures were applied to another topography. For five participants (Mike, Jordan, Ali, Luke, and Milly), there was an immediate level increase in total problem behavior as some responses were removed from the contingency class. For two participants (Cole and Raj), a gradual level increase in total problem behavior was observed as more responses were removed from the reinforcement contingency class. For Bill and Annie, no change in the level of total problem behavior was observed as responses were removed from the contingency class. For Caleb, there was a gradual decrease in the level of total problem behavior as extinction was applied to one topography. We also measured emotional responding for three participants (Raj, Jordan, and Mike) and found that for all three participants, levels of emotional responding were high when the contingency class was relatively closed. It is unclear whether the emotional responding observed was a side effect of extinction or if the responses were members of the
Figure 14. Total problem behavior during the extinction analyses across all participants and the percentage of session with emotional responding during the extinction analyses for Mike, Jordan, and Raj.
same response class as the other forms of problem behavior. For all participants except Caleb, the forms of problem behavior were more severe when the reinforcement contingency was relatively closed.

DISCUSSION

Systematic extinction procedures revealed that the most concerning topography was sensitive to the same synthesized reinforcement contingency as other topographies of problem behavior that were reported to co-occur by caregivers in nine of 10 participants (one outcome was ambiguous). By extension, when caregivers reported that the child engaged in different forms of problem behavior in similar situations, these different forms were likely to be the members of the same response class. Considering the consistency of results obtained within a CCCSD, in which any negative or anomalous effects were reported, our results suggest that control of at least one topography of problem behavior in a single FA is probably sufficient for proceeding to the evaluation of a function-based treatment for children who engage in multiple topographies of problem behavior reported to co-occur in similar situations.

Because the study was conducted across three sites with male and female children of varying ages, communication skills, and diagnoses who exhibited multiple topographies of problem behavior, the notion that problem behaviors reported to co-occur in similar situations are members of the same response class appears to have strong generality. This notion is further supported by the fact that these results are consistent with 12 of 13 other studies that have analyzed response class membership of multiple topographies of problem behavior (Borlase et al., 2017; Borrero & Borrero, 2008; DeRosa et al., 2013; Fritz et al., 2013; Harding et al., 2001; Herscovitch et al., 2009; Lalli et al., 1995; Langdon et al., 2008; Lieving et al., 2004; Magee & Ellis, 2000; Richman et al., 1999; Smith & Churchill, 2002; Thompson et al., 1998).

The current study included synthesized response topographies in addition to synthesized EOs and reinforcers, representing an extension of response class membership research. This extension to the synthesized reinforcement literature is important as we begin to understand the prevalence of synthesis in the FA and treatment literature. In their review of synthesis in analyses, Slaton and Hanley (2018) found that at least 120 synthesized contingency analyses had been published as of January 2018 and that open-contingency classes were highly prevalent, in that 81% of synthesized contingency analyses included an open-contingency class. One must acknowledge the possibility that different responses may be controlled by different reinforcers when an open-contingency class is programmed, and reinforcers are synthesized. However, given that the results of the current CCCSD are consistent with the majority of studies that have evaluated response class membership using isolated reinforcers (Borlase et al., 2017; Borrero & Borrero, 2008; DeRosa et al. 2013; Fritz, et al., 2013; Harding et al., 2001; Herscovitch, et al., 2009; Lalli, et al., 1995; Langdon et al., 2008; Lieving et al., 2004; Magee & Ellis, 2000; Richman et al., 1999; Smith & Churchill, 2002), it seems unlikely that the use of synthesized reinforcers moderated the high likelihood of response class membership.

The validity of conclusions from synthesized reinforcement contingencies with an open-contingency class is also supported by recent treatment effectiveness studies. Beaulieu, Clausen, Williams, and Herscovitch (2018), Rose and Beaulieu (2019), Hanley et al. (2014), Herman, Healy, and Lydon (2018), Jessel et al. (2018), Taylor, Phillips, and Gerzog (2018), Santiago, Hanley, Moore, and Jin (2016), and Strand and Eldevik (2017) all described socially validated outcomes of function-based treatments.
designed from single-test analyses that arranged interview-informed synthesized reinforcement for open-contingency classes. Treatments from these studies included practical schedules of reinforcement and were implemented by caregivers in relevant contexts by the close of each study. These same outcomes have not, to our knowledge, been reported from approaches involving multiple analyses distinguished by topography.

Although we referred to them as extinction analyses, we did not apply extinction for enough sessions to allow responses to extinguish. Rather, our focus was the emergence of other forms of problem behavior as the procedure of extinction was sequentially applied to topographies of problem behavior. Safety and efficiency were key factors in this decision. In this way, Catania’s (2007) definition of response class membership was expanded to include evocation and maintenance of a response by the same contingency. The failure to extinguish responses should, however, be considered when concluding that the results demonstrated that the most concerning topography showed sensitivity to the same synthesized contingency as the less concerning topographies for nine of 10 participants.

It is plausible that some responses that did not extinguish were automatically reinforced. Including automatically maintained problem behavior in the programmed reinforcement contingency is a concern because it may result in an undifferentiated analysis (e.g., Derby et al., 1994; Thompson et al., 1998). We attempted to minimize the possibility of outcomes being affected by automatically reinforced behavior by relying on the question in the interview to distinguish potentially self-stimulatory responses from socially mediated responses, analyzing each topography separately (Derby et al. 1994), and conducting within-session analyses when a possible pattern of self-stimulatory behavior was detected (Figure 3).

Although complete extinction was rarely observed in our analyses (e.g., Raj’s covering face and ears), indirect effects of extinction (Lerman & Iwata, 1996) were evident. We observed increased variability in responding as extinction was applied (e.g., Cole’s whining, disruption, disruptive vocalizations) consistent with research on variability produced by extinction (Lattal, St. Peter, & Escobar, 2013). We also observed patterns (e.g., Cole’s whining and disruption) seemingly indicative of resurgence (Bruzek, Thompson, & Peters, 2009; Lattal et al., 2013). It is challenging to distinguish between extinction-induced variability and resurgence in our analyses. However, because all responses were reported by caregivers, presumably the participants had a history of reinforcement for all responses making it more likely that the increases observed were examples of resurgence.

We observed additional patterns of responding that have important implications for practitioners. Higher rates of total problem behavior (Figure 10) and increases in the most concerning topography were typically observed when the reinforcement contingency was relatively closed. The practical implication is that an open-contingency class seems optimal given that an understanding of the most concerning topography may be evident without observing high rates of problem behavior or the most concerning topography in the analysis.

We also found that closed-contingency classes were more likely to yield emotional responding (Figure 13) and rarely-witnessed aggression (Figure 6). Regardless of whether emotional responding was categorized as a side effect or as another member of the response class and whether aggression was induced or another member of the response class with a history of reinforcement, the implication is that open-contingency classes allow for control of problem behavior without responding that may socially invalidate the analysis results.

Ali was the only participant for whom we consistently observed the most concerning topography (aggression) during the FA. However, we also
observed unreinforced responses that produced longer latencies to the target behavior (see bottom panel of Figure 7). Responses that fall above the threshold but below criterion have been referred to as subcriterion responses (Pinkston & Libman, 2017). The implication for applied work is that rates of target behaviors may often be an artifact of the criterion. Ali’s analysis demonstrates one way in which there is an unavoidable degree of speculation involved with the selection of target responses.

Extinction analyses are an interpretation safeguard when only one of multiple topographies of problem behavior is observed during an FA. However, given the results of the current and previous studies show that topographies of problem behavior that are reported to co-occur are most often members of the same response class (Borlase et al., 2017; Borrero & Borrero, 2008; DeRosa et al., 2013; Fritz et al., 2013; Harding et al., 2001; Herscovitch et al., 2009; Lalli et al., 1995; Langdon et al., 2008; Lieving et al., 2004; Magee & Ellis, 2000; Richman et al. 1999; Smith & Churchill, 2002), practitioners need not be compelled to conduct extinction analyses and should instead consider making the inference that the reinforcement contingency controlling the observed topography is the same as that controlling other topographies that interviewees report co-occur in similar situations. This recommendation to rely on inference is grounded in the empirical evidence that an inferential error is not likely and occasioned by concerns for client and analyst safety when using closed-contingency classes.

In the case that caregivers request verification of response class membership of the most concerning topography prior to moving to treatment because it was not observed during the FA, we suggest that the brief extinction analysis be implemented. Furthermore, the expedited extinction analysis should probably only be used only when results of the brief extinction analysis are not clear. Rather than conducting extinction analyses, response to treatment also may be used as verification of response class membership. That is, practitioners can measure forms of problem behavior separately during the FA and treatment to affirm the response class interpretation (e.g., Dracoby & Smith, 2012; Fritz et al. 2013; Hoffman, Sellers, Halversen, & Bloom, 2018; Najdowski, Wallace, Ellsworth, MacAleese, & Cleveland 2008). An inferential error would be revealed in treatment if a topography persists despite treatment effects for other topographies.

REFERENCES


*Received May 18, 2018*
*Final acceptance March 22, 2019*
*Action Editor, Matthew Normand*

**SUPPORTING INFORMATION**

Additional Supporting Information may be found in the online version of this article at the publisher’s website.