Expanding Functional Analysis of Automatically Reinforced Behavior Using a Three-Component Multiple-Schedule

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Current functional analysis methodology provides the general label "automatic reinforcement" for behaviors that persist in the absence of social consequences. Likewise, current treatment-evaluation methods may demonstrate that a given intervention decreases automatically reinforced behavior. However, neither yields results that indicate whether an intervention contains stimulation that is functionally matched to the product of automatically reinforced behavior. We present a sequential assessment model to evaluate interventions for automatically reinforced behavior using a three-component multiple-schedule. This three-component multiple-schedule can be used to identify interventions that produce an abolishing operation for subsequent engagement in automatically reinforced behavior. We provide a step-by-step description of the procedures and data analysis, as well as a general overview of our findings to date. The potential clinical utility of the methodology and applications for future research are also discussed.

Key words: automatic reinforcement, functional analysis, motivating operations, multiple-schedule, stereotypy

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The results from a traditional functional analysis (e.g., Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994; Vollmer, Marcus, Ringdahl, & Roane, 1995) typically indicate whether a behavior is socially or nonsocially reinforced. Hagopian et al. (1997) suggested that at least three patterns from a functional analysis indicate that the target behavior is nonsocially or automatically reinforced. These three patterns are as follows: (a) highest levels of the behavior are observed during the no-interaction conditions and comparatively low levels during the control conditions; (b) high and variable levels of the behavior across all conditions; or (c) high levels of the behavior during conditions in which ambient stimulation is generally low. Although these criteria can help clinicians determine when a behavior is automatically reinforced, current functional assessment methodology is limited because sources of reinforcement that could potentially substitute for the sensory product of the behavior are not identified. Therefore, the reinforcing stimulation that is generated by such behavior cannot be delivered

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independent of the target behavior, contingent on the omission of the target behavior, or contingent on an alternative behavior (Rapp & Vollmer, 2005; Vollmer, 1994). Likewise, the consequent stimulation cannot be directly withheld.

As a result, clinicians and researchers must rely on indirect methods to infer a possible sensory function of automatically reinforced behavior. For example, some studies have utilized sensory extinction procedures to isolate specific nonsocial consequences that maintained automatically reinforced behaviors (e.g., Kennedy & Souza, 2005; Rapp, Miltenberger, Galensky, Ellingson, & Long; 1999, Rincover, Cook, Peoples, & Packard, 1979). As a whole, procedures that are intended to separate automatically reinforced behavior from the consequent sensory stimulation can be time-consuming and complex. Moreover, even if such procedures identify a potential sensory consequence that contributes to the maintenance of the target behavior, additional procedures are typically needed to evaluate a suitable function-based intervention that includes alternative sources of reinforcement (for an example, see Kennedy & Souza). Thus, there is a need for further development of a behavior-analytic methodology to empirically identify nonsocial reinforcers for problem behavior.

One popular treatment for automatically reinforced behavior consists of providing noncontingent access to competing stimulation (Carr et al., 2000; Leblanc, Patel, & Carr, 2000; Rapp & Vollmer, 2005). Numerous studies have shown that continuous access to preferred stimulation decreases immediate levels of automatically reinforced behavior (e.g., Ahearn, Clark, DeBar, & Florentino, 2005; Piazza, Adelinis, Hanley, Goh, & Delia, 2000; Rapp, 2007; Vollmer, Marcus, & LeBlanc, 1994). However, treatments that are based on noncontingent reinforcement do not necessarily contain stimulation that is similar to the consequent event that maintains the automatically reinforced behavior. That is, even though access to or delivery of a preferred stimulus decreases immediate levels of an automatically reinforced behavior, it is typically not known whether the removal of the preferred stimulus occasions decreased or increased engagement in the automatically reinforced behavior.

Based on this problem, some recent studies have deliberately evaluated the extent to which access to preferred stimulation decreases subsequent engagement in automatically reinforced behavior (e.g., Lanovaz, Fletcher, & Rapp, 2009; Rapp, 2006, 2007; Simmons, Smith, & Kliethermes, 2003). To this end, Rapp and colleagues (i.e., Rapp, 2007; Lanovaz et al.) make a distinction between two types of interventions, structurally matched and functionally matched interventions. A structurally matched intervention delivers stimuli that match the putative sensory product of the target behavior. In contrast, a functionally matched intervention should produce effects similar to those produced by prior access to the target behavior (see Lang et al., 2009; Rapp, 2004). That is, the removal of a "functionally matched" intervention should occasion either (a) continued reductions in the target behavior or (b) increases in the target behavior that do not exceed prior baseline levels. Ideally, a functionally matched intervention would also decrease automatically reinforced behavior when it was present. Nonetheless, because interventions with dense schedules may compete with engagement in academic programming in much the same way as engagement in automatically reinforced problem behavior, what happens to the target behavior after preferred stimuli are removed may be more important than what happens when the stimuli are present (Lanovaz et al.).

In the case of automatically reinforced behavior, the response-reinforcer relation is linked in such a way that changes in the rate or duration of a target behavior are likely to be indicative of changes in the reinforcing-value of engaging in automatically reinforced behavior (Rapp, 2008). That is, decreases in an individual's engagement in an automatically reinforced behavior signify the decreased value of the sensory stimulation that is generated by the respective behavior (and vice versa). Based on the concepts described by Laraway, Snycerski, Michael, and Poling (2003), abolishing operations (AOs) decrease the reinforcing-value of stimulation generated by and engagement in automatically reinforced behavior, whereas establishing operations (EOs) increase the reinforcing-value of the stimulation generated by and engagement in automatically reinforced behavior. Both EOs and AOs are subsumed by the larger concept of motivating operations (MOs; Laraway et al.). When evaluating the effects of an intervention on automatically reinforced behavior, the effects of MOs can be further subcategorized as either “immediate” or “subsequent.” Specifically, immediate MOs alter levels of the target behavior while an intervention is in place, whereas subsequent MOs alter levels of the target behavior after the intervention has been withdrawn.

An intervention containing stimulation that is functionally dissimilar to the stimulation generated by an automatically reinforced behavior may decrease an individual’s engagement in that behavior; however, the intervention may impose deprivation for the stimulation that was generated by the automatically reinforced behavior. This deprivation may be evidenced by increased engagement in the target behavior following the removal of the intervention (see Timberlake & Allison, 1974). That is, imposing deprivation for stimulation produced by automatically reinforced behavior may produce a subsequent EO for engagement in the automatically reinforced behavior. For example, Rapp (2006, 2007) has shown that restricting an automatically reinforced behavior produced an EO for subsequent engagement. Similarly, Ahearn, Clark, Gardenier, Chung, and Dube (2003) found that levels of automatically reinforced behavior were higher following access to preferred stimuli on a VT schedule than following a period of no access to the stimuli.

As an extension of the methodology provided by Simmons et al. (2003), we describe the use of three consecutive components (of equal duration) within two or more specified sequences (a given sequence is comprised of three components) to identify functionally matched interventions for automatically reinforced problem behavior. To ensure maximum sensitivity for detecting changes in MOs, we recommend that evaluators use continuous duration recording or momentary time sampling with 10-s intervals for duration events (Meany-Daboul, Roscoe, Bourret, & Ahearn, 2007; Rapp et al., 2007; Rapp, Colby-Dirksen, Michalski, Carroll, & Lindenberg, 2008) and continuous frequency recording or partial-interval recording with 10-s intervals for frequency events (Meany-Daboul et al.; Rapp et al., 2008). What follows is a detailed account of how three-component multiple-schedules can be used to identify functionally matched interventions for automatically reinforced behavior. Toward this end, we provide examples of the three patterns that we have encountered in our research and clinical work.

Using Multiple-Schedules to Identify Functionally Matched Interventions

Data collected within multiple-schedules can be analyzed in at least two ways to identify an intervention that decreases engagement in automatically reinforced behavior. First, patterns across sequences for each component can be examined for the immediate and subsequent effects of an intervention. For example, the third component of a baseline sequence can be compared to the third component of a test sequence to determine the subsequent effects of the stimulus on the target behavior; this is referred to as a between-sequence analysis. Second, patterns within the test sequence can be examined to determine the effects of the intervention on subsequent engagement in the automatically reinforced behavior (i.e., after it is removed). For example, levels of the target behavior in the first and third components of a test sequence can be compared to examine whether the intervention decreases subsequent engagement in the target behavior. Inspection of data in this manner is referred to as a within-sequence analysis. The between-sequence analysis is conducted first because it shows stronger experimental control by comparing responding in each component of the respective sequences and is sensitive to both molecular and molar patterns of behavior. By contrast, the within-sequence is sensitive to only molecular patterns.

Figure 1 displays a sequential assessment model for the functional analysis of automatically reinforced behavior. The first step involves conducting a traditional functional analysis or a series of no-interaction conditions to identify the 'general' function of the behavior. If the assessment shows that the behavior persists in the absence of social consequences (e.g., Iwata & Dozier, 2008; Vollmer et al., 1995), the second step is to conduct a stimulus preference assessment (SPA) to identify a preferred stimulus that will be used as part of an intervention to reduce the target behavior. When continuous access to a preferred stimulus is provided during the second component of the test sequence, a duration-based SPA such as the free-operant stimulus preference assessment (e.g., Roane, Vollmer, Ringdahl, & Marcus, 1998) should be conducted to increase the likelihood that the individual will interact with the stimulus during most if not all of the component. When access to the preferred stimulus is not continuous (e.g., differential reinforcement of an alternative behavior, time-based delivery of preferred edible items), a trial-based SPA such as the paired-choice stimulus preference assessment (Fisher et al., 1992) or the multiple-stimulus without replacement preference assessment (DeLeon & Iwata, 1996) should be conducted because the conditions under which the stimuli are selected (i.e., several trials of short durations) more closely approximate the conditions under which the stimuli are delivered in the intervention. Generally, a highly preferred stimulus that matches the putative, overt sensory product of the automatically reinforced behavior should be provided as part of the intervention first because the stimulus is more likely to decrease the automatically reinforced behavior (Lanovaz et al., 2009; Piazza et al., 2000; Rapp, 2007; but see Ahearn et al., 2005). During the intervention, the preferred stimulus can be provided independent of the target behavior, contingent on the absence of the target behavior, or contingent on an alternative behavior.

The third step is to alternate a baseline sequence with a test sequence in a pairwise fashion. Each of the two sequences contains three components of equal duration (e.g., 10 min). Specifically, the stimulus identified from the preference assessment is presented only during the second component of the test sequence.

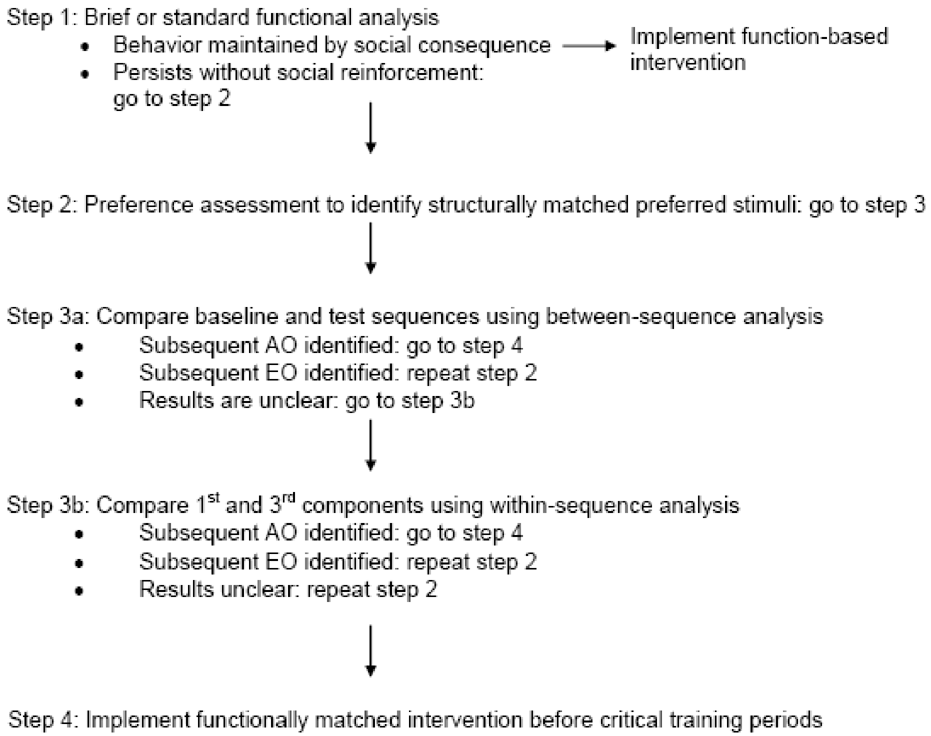

Figure 1. Sequential assessment model for the functional analysis of automatically reinforced behavior.

The alternation of the two sequences should be conducted in a pseudo-random fashion to ensure that each sequence is conducted during a comparable number of sessions. We recommend conducting three to six sessions for each sequence to avoid false positives (i.e., chance differentiation in data paths for components from the respective sequences). In the baseline sequence, the three components are no-interaction (NI) conditions during which intervention is absent (i.e., no social consequences are provided for engaging in the target behavior). The baseline sequence is needed to evaluate possible changes in automatically reinforced behavior across the three components in the absence of programmed intervention. In the test sequence, the first and third components are also NI conditions, but the second component involves the intervention; in this example, the intervention is continuous or FT presentation of an empirically identified preferred stimulus.

In multiple-schedules, each component with a different intervention or schedule is signaled by a specific discriminative stimulus (e.g., Reynolds, 1961). In the assessment of functionally matched interventions, the items related to the intervention (e.g., the presence of preferred stimuli, proximity of the trainer, or colored poster boards) within the components serve as the discriminative stimuli in the intervention component, and the context (e.g., absence of preferred stimuli or trainer) serves as the discriminative stimulus in the NI components. The differences between the two types of components (i.e., presence vs. absence of intervention) should be sufficiently salient to signal the schedule.

When plotted in line graphs, the data paths from the first components of each sequence should be undifferentiated because the components are conducted in the absence of an intervention. If the first components are differentiated, additional sessions should be conducted until the components are undifferentiated. Next, between-sequence patterns should be examined for differentiation in the data paths during the second components and the third components of the baseline and test sequences.

In terms of identifying an intervention that produces a subsequent AO for engagement in automatically reinforced behavior, we have argued that what occurs in the third component (after the intervention is removed) of the test sequence is more important than what occurs in the second component (when the intervention is present) of the test sequence. Nonetheless, assume that the intervention decreases the target behavior during the second component of the test sequence in comparison to the second component of the baseline sequence. This outcome would suggest that the intervention produced an immediate AO for automatically reinforced behavior. Given this result for the second components of the two sequences, there are three possible outcomes for the third components. First, the target behavior is lower in the test sequence than in the baseline sequence. This pattern suggests that the intervention produced an AO for subsequent engagement in automatically reinforced behavior (proceed to Step 4). Second, the target behavior is higher in the test sequence than in the baseline sequence. In combination with the results from the second components, this pattern suggests the intervention produced an EO for subsequent engagement in the automatically reinforced behavior; the clinician or researcher should conduct a new SPA (return to step 2) and repeat step 3 with a different stimulus, a different intervention, or both. Third, the data paths for the third components of the two sequences are undifferentiated. To further evaluate possible changes in MOs as a function of the intervention, a within-sequence analysis should be conducted (see Figure 1: Step 3b). If the results of the within-sequence analysis of the test sequence reveal that the second component is typically the lowest, and that the third component is lower than the first component, this pattern would suggest that the intervention produced an AO for the target behavior. The clinician or researcher should proceed to step 4. By contrast, if the aforementioned pattern is not detectable or the third component is typically higher than the first component, which suggests that the intervention produced an EO for subsequent engagement in the target behavior, the evaluator should return to step 2.

To illustrate the process of using between- and within-sequence analyses to evaluate automatically reinforced behavior, we provided examples of different behavior patterns that have been produced when preferred stimuli were presented as a part of an intervention in the second component of a multiple-schedule. In the next two sections, we present representative data sets for three individuals who engaged in automatically reinforced problem behavior. For the remainder of this paper, we generically refer to each participant's automatically reinforced problem behavior as the "target behavior." Likewise, we referred to the preferred stimulus that is provided in the second component of the test sequence as the "intervention." Specific details about the analyses that are conducted in step 3 are provided in the following two sections.

Between-Sequence Analysis

To examine the immediate and subsequent effects of an intervention, levels of the target behavior in each component can be compared across sequences. Figure 2 contains line graphs with the percentage of time each individual engaged in the target behavior across the first, second, and third components of baseline and test sequences within multielement designs. Ideally, the data paths for the first components (left panels of Figure 2) should be undifferentiated to verify that each sequence contains comparable levels of the target behavior prior to introducing the intervention. Differentiated data paths during the first component would indicate that an extraneous variable systematically influenced the target behavior in one or both of the sequences or that an insufficient number of

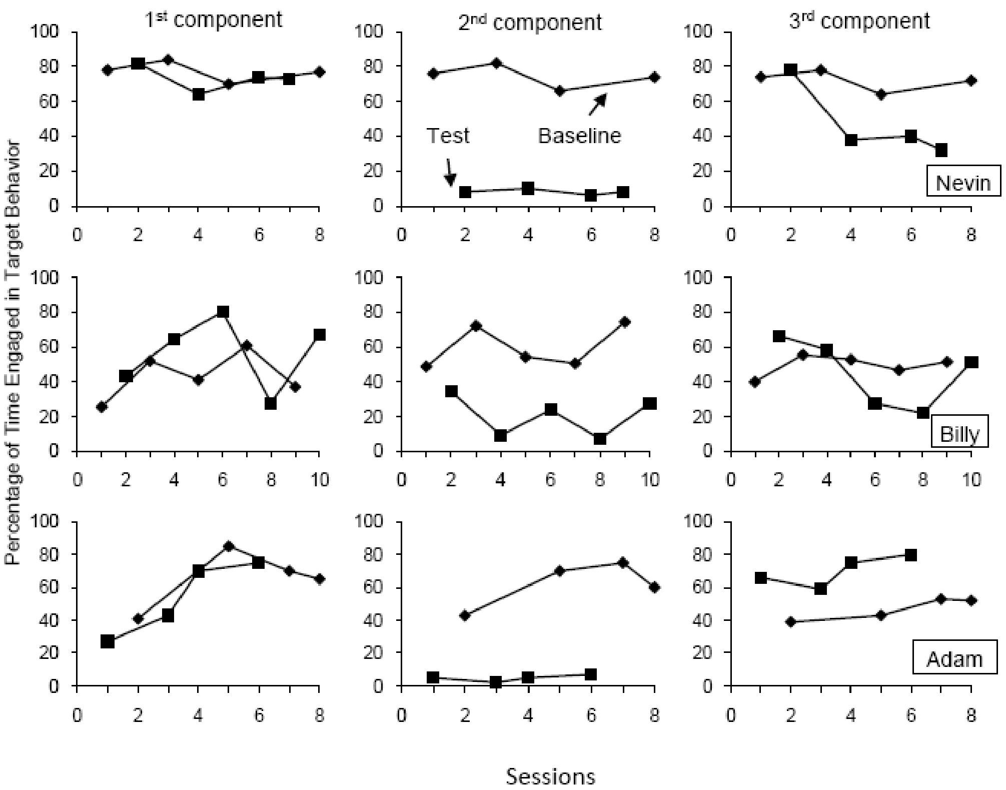

Figure 2. Between-sequence analysis showing the percentage of time Nevin (three upper [from left to right] panels), Billy (three center panels), and Adam (three lower panels) engaged in the target behavior across the first (left [from top to bottom] panels), second (middle panels), and third (right panels) components of baseline and test sequences.

sessions have been conducted (i.e., the apparent differentiation is an example of chance).

The second components (middle panels [from top to bottom] of Figure 2) show whether the intervention decreased immediate levels of the target behavior. Figure 2 shows that levels of the target behavior were always lower in the second component of the test sequence than in the second component of the baseline sequence for Nevin, Billy, and Adam, indicating that the intervention decreased immediate levels of the target behavior for each participant. However, the results from the second components alone do not indicate whether the intervention produced an AO for subsequent engagement in the target behavior. An examination of patterns during the third component is necessary to address this issue.

As previously noted, levels of the target behavior during the third component (right panels of Figure 2) may conform to one of three patterns. The third component of the test sequence may be lower than the third component of the baseline sequence. Regardless of the immediate effects of the intervention in the second component, such a pattern would indicate that the intervention produced a subsequent AO for engagement in the target behavior. For example, Nevin's data (upper middle and upper right panels) show that levels of the target behavior were typically lower in the test sequence than in the baseline sequence during the second and the third components, suggesting that the intervention produced an AO for immediate and subsequent engagement in the target behavior. Alternatively, as shown with Billy's target behavior, the data paths for the third components of the baseline and test sequences (center, right panel of Figure 2) may be relatively undifferentiated. To some extent, this pattern may also be desirable because it indicates that the intervention had the same effects on the target behavior as providing access to the stimulation generated by the target behavior (i.e., removal of the intervention did not occasion increased engagement in the target behavior). However, as highlighted in Figure 1, further analysis of within-sequence patterns is warranted for Billy's target behavior. Thus far, we have found that a majority of our data sets require a within-sequence analysis in order to identify subsequent AOs or EOs for automatically reinforced behavior (see section below on within-sequence analysis).

Finally, access to the preferred stimulus in the second component of a test sequence may increase engagement in the target behavior during the third component of the test sequence. For example, Adam's data show that the intervention decreased the target behavior during the second component (lower, middle panel), but increased the behavior during the third component (lower, right panel); this outcome suggests that the intervention produced a subsequent EO for engagement in the target behavior. To date, this outcome has been least common with our participants; however, our treatment evaluations have been primarily limited to continuous delivery of highly preferred items. Thus, this between-sequence EO pattern may occur more frequently with interventions that have not yet been evaluated with the methodology.

When the differences between the third components are clear, data analysis can stop at the between-sequence level. If an intervention produces an AO for subsequent engagement in automatically reinforced behavior (as for Nevin), it should be used in a broader function-based intervention (move to step 4). By contrast, additional assessments should be conducted with different stimuli if the preferred stimulus produces an EO for subsequent engagement in the behavior (as for Adam).

Within-Sequence Analysis

In a manner not unlike a within-session analysis of data collected with a traditional functional analysis (see Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993), a within-sequence analysis of the three components in the test sequence may be conducted to clarify the results from between-sequence analyses (as for Billy). Recall that the intervention is only presented in the second component of the test sequence. The comparison of the third component with the first component may indicate whether the intervention produces an AO or an EO for subsequent engagement in the target behavior. That is, a pattern wherein the third component was typically lower than the first component in the test sequence would indicate that the intervention produced an AO for subsequent engagement in the behavior. By contrast, a pattern wherein the third component was typically higher than the first component would indicate that the stimulus produced as an EO for subsequent engagement in the behavior.

Figure 3 (upper panel) depicts the data for Billy's target behavior during each component within baseline and test sequences (5 sessions of each) in bar graphs to facilitate a visual inspection of within-sequence patterns. The results for Billy's target behavior show that the third component was lower than the first component for 4 of 5 test sequences. By contrast, the same pattern was not produced by the baseline sequence. The results of this analysis suggest that the intervention produced a subsequent AO for Billy's engagement in the target behavior. Based on our findings to date, this is the most common outcome for

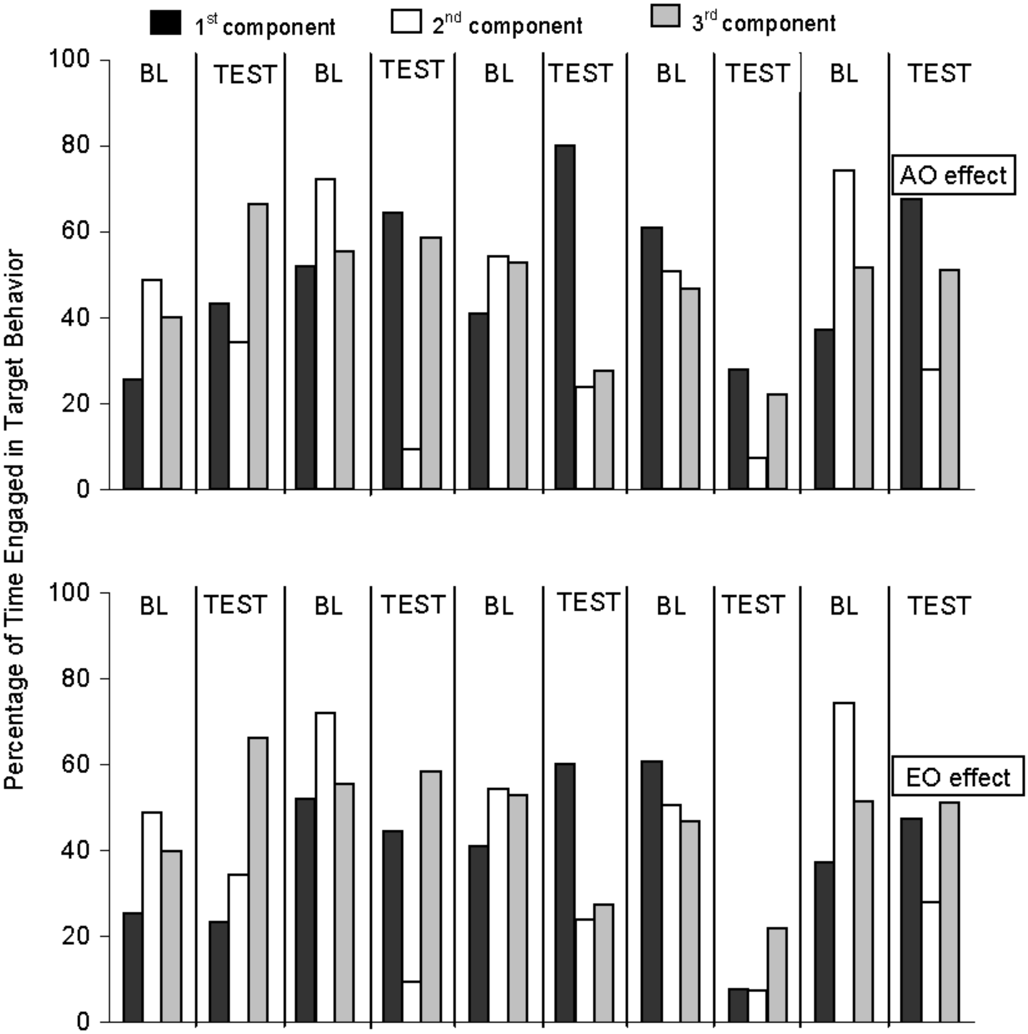

Figure 3. Within-sequence analysis showing the percentage of time Billy engaged in the target behavior across the first, second, and third components of baseline (BL) and test sequences (upper panel). Within-sequence analysis of Billy's target behavior with modified data for the first components of the test sequence to illustrate an EO pattern for subsequent engagement in the target behavior (lower panel).

empirically identified preferred items that are structurally matched to a given automatically reinforced behavior.

For purposes of additional illustration, Figure 3 (lower panel) shows alternative data for Billy (we systematically decreased the actual level of the target behavior by 20% in the first component of each test sequence). Following our alteration of the data in the first component, the within-sequence analysis shows that his behavior was *higher* in the third component than in the first component for 4 of 5 test sequences, which suggests that the intervention produced an EO for subsequent engagement in the target behavior. Again, by comparison, the same pattern is not evident in the baseline sequences. Based on this hypothetical outcome, it would have been necessary to conduct a new SPA and repeat step 3 in an attempt to identify an intervention that produced both an immediate and subsequent AO for Billy's behavior.

Conclusions

The proposed sequential model of functional analysis provides a potential extension of current methodology for evaluating automatically reinforced problem behavior. To date, we have utilized this methodology to evaluate the effects of interventions for approximately 20 individuals. For a majority of these participants, we identified a subsequent AO using the within-sequence analysis; however, we also identified a subsequent EO for a handful of participants via between-sequence analyses and within-sequence analysis. By using the three-component methodology, behavior analysts can implement interventions that decrease an individual's immediate and subsequent engagement in automatically reinforced problem behavior.

On a practical level, interventions that produce both immediate and subsequent AOs for automatically reinforced behavior can be provided prior to critical training periods so that motivation to engage in automatically reinforced behavior is minimized during training. It seems reasonable to make the assumption that reducing the amount of time an individual engages in automatically reinforced behavior should increase the amount of time the individual engages in other behavior (e.g., listening to instructions, completing tasks) to contact other reinforcers (e.g., edibles, attention). Preliminary results obtained by Lang et al. (2009) suggest that interventions that decrease subsequent engagement in automatically reinforced behavior may also increase engagement in appropriate play behavior. Nonetheless, future research examining the effects of treatment on subsequent engagement in socially appropriate behavior should be conducted to provide additional support for the methodology.

The methodology described in this paper is potentially limited insofar as it is theoretically predicated on the assumption that the target behavior is maintained by automatic positive reinforcement. Although recent review papers on the assessment and treatment of automatically reinforced behavior support our assumption (LeBlanc et al., 2000; Rapp, 2008; Rapp &Vollmer, 2005), it is not clear whether this methodology will be useful for evaluating behavior that is maintained by automatic negative reinforcement. In addition, all of our data sets were collected during daily 30-min sessions that were conducted within a pre-specified 2-hour window of time. Currently, it is not known whether the same results can be obtained by conducting multiple sessions on a given day or by altering the times at which sessions are conducted across days. Therefore, additional research is needed to determine the amount of flexibility with which this methodology can be used to assess automatically reinforced behavior.

Future research on multiple-schedules should also examine the optimal component durations to determine whether the duration of the assessment can be decreased. As suggested by Simmons et al. (2003), future research should also expand the use of the methodology by assessing the effects of other treatments on subsequent engagement in problem behavior and by conducting research under a variety of conditions. For example, the three-component multiple-schedule can be used to evaluate the effects of punishment or response blocking on automatically reinforced behavior (see Rapp, 2006, 2007). The methodology could also be extended to verify the social functions of problem behavior. As an example for attention-maintained problem behavior, a trainer could provide noncontingent or contingent (as in functional communication training) attention during the second component of a three-component multiple-schedule to determine whether an AO for attention-maintained problem behavior is generated in the third component. The increased use of multiple-schedules may not only benefit individuals who emit problem behavior by providing a thorough assessment of their behavior, it may also benefit applied behavior analysis as a science by expanding the realm of functional analysis.

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