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Analysis of unexpected disruptive effects of contingent food reinforcement on automatically maintained self-injury

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Abstract

Research has identified treatment-responsive and treatment-resistant subtypes of automatically maintained self-injurious behavior (ASIB) based on patterns of responding in the functional analysis (FA) reflecting its sensitivity to disruption by alternative reinforcement, and the presence of self-restraint. Rooker et al. (2019) unexpectedly observed reductions in treatment-resistant self-injury while participants performed an operant task. The current study further examined this in nine participants with treatment-resistant ASIB in an example of discovery-based research. An operant task engendering high rates of responding (switch-pressing) to produce food, reduced self-injury across all participants, and eliminated self-injury for some participants under certain schedules. Although this finding must be replicated and evaluated over longer time periods, it provides some evidence that alternative reinforcement can disrupt self-injury in these treatment-resistant subtypes under some conditions. Reinforcer and response competition are discussed as possible mechanisms underlying these disruptive effects, as are the potential implications of these findings regarding treatment.

Keywords

automatically maintained self-injury; reinforcer competition; response competition

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Recent research has identified treatment-responsive and treatment-resistant subtypes of automatically maintained self-injurious behavior (ASIB; Hagopian et al., 2015, 2017). When a high level of differentiation in the rate of self-injurious behavior (SIB) is observed across the play and no interaction conditions of a functional analysis (FA; Subtype 1), treatment using reinforcement alone is far more efficacious in comparison to when rates of SIB are comparable across the play and no interaction conditions during an FA (Subtype 2), or when individuals engage in frequent self-restraint (Subtype 3). Consequently, the use of protective equipment, response blocking, and restraint are often necessitated in the treatment of Subtypes-2 and -3 ASIB. These findings suggest that the sensitivity of ASIB to disruption by alternative reinforcement is a dimension of responding that has generality across FA and treatment contexts.

Pursuant to this observation, Rooker et al. (2019) examined whether the relative insensitivity of SIB to alternative reinforcement, which is characteristic of Subtype 2, was specific to that response class or whether it was a generalized response tendency evident across other response classes (e.g., problem and non-problem behaviors, maintained by the same or different reinforcers). If diminished sensitivity to alternative reinforcement is evident only for SIB, it might suggest that SIB produces highly potent reinforcement against which alternative reinforcement cannot compete. It is also possible that this invariant subtype of SIB may be the product of motor or sensory dysfunction (Hagopian & Frank-Crawford, 2018), in which case this pattern of responding might only be present for this behavior (for additional discussion, see Muehlmann & Lewis, 2012). However, if the relative insensitivity of SIB to alternative reinforcement in this subtype is also present across other response classes, this would suggest the presence of a generalized response tendency in individuals with this subtype. Generalized response tendencies have been associated with other clinical conditions such as autism (invariance; Rodriguez et al., 2012), attention deficit hyperactivity disorder (impulsivity; Neef et al., 2005), anxiety (inhibition; Rosenbaum et al., 1993), and psychopathy (diminished sensitivity to punishment; Newman et al., 1987).

As a preliminary examination of the potential that the invariant SIB observed in these individuals was a generalized response tendency, Rooker et al. (2019) compared the performances of participants with Subtype-2 ASIB to those with socially maintained SIB (specifically, tangibly maintained SIB; a behavior that is highly sensitive to disruption by alternative reinforcement in both the FA play and treatment conditions). An arbitrary response (switch-pressing) was first established under a continuous schedule of food reinforcement and then progressive ratio (PR) and extinction (EXT) schedules were applied. The use of various schedules of reinforcement (continuous, PR, and EXT) was a key feature of this study, as it sought to examine the sensitivity of behavior to changes in reinforcement. Sensitivity was defined broadly as a change in response patterning following an experimental manipulation (Madden et al., 1998). The PR and EXT schedules were employed, as the effects of these schedules on behavior are well established (e.g., Lerman & Iwata, 1996; Roane, 2008). Further, transitions between reinforcement schedules were not signaled. This provided a more conservative test of the participants' sensitivity to changes in reinforcement. All participants demonstrated some change in response patterning following shifts from continuous reinforcement to PR or EXT schedules, which indicated there was no apparent difference in sensitivity across participants with Subtype-2 ASIB relative to those with socially maintained SIB. Although further replication is necessary, the findings suggest the relative insensitivity of Subtype-2 ASIB to disruption by alternative reinforcement appears to be specific to that response class and is not a generalized response tendency among individuals with this functional class of behavior.

Within the context of conducting Rooker et al. (2019), we encountered an unexpected effect in which there were marked reductions in the occurrence of SIB among those with Subtype-2 ASIB when these individuals were engaging in the arbitrary response. This finding was notable for two reasons. First, resistance to change is the hallmark of this subtype (Hagopian et al., 2017); thus, identifying a condition in which this behavior changed as the result of a change in the environment was notable. Second, these results suggest that the arrangement used in Rooker et al. (2019) may be a means to compete with SIB in this subtype. However, the mechanism of competition was not clear. It is possible that engaging in the task may have interfered with the occurrence of SIB, via response competition. It is also possible, that the consumption of a higher quality reinforcer may have attenuated the motivating operation for the putative reinforcer for SIB via reinforcer competition.

The purpose of the current study was to further examine the reductive effects produced by engagement in an operant task that engendered high rates of responding to produce food reinforcement. Thus, we replicated and extended Rooker et al. (2019) with additional participants with Subtypes-2 and -3 ASIB and examined how the occurrence of SIB was affected under various schedules on an operant task involving food reinforcement. After this, a within-session pattern analysis was conducted to compare SIB across different conditions and to examine the degree to which patterns of responding suggested that a specific mechanism was responsible for the observed response reductions. In particular, we sought to identify patterns that were suggestive of reinforcer or response competition. The current research is an example of discovery research (e.g., Tiger & Hanley, 2005) in that it examines an unexpected effect observed during a procedure.

Method

Participants, Setting, and Materials

The inclusion criteria were that individuals had been admitted to the neurobehavioral unit and that participants were reported to engage in SIB. The participants in this study were a subset of those individuals, whose SIB was determined to be maintained by automatic reinforcement and who experienced the procedure described below. Participants were those that were determined to engage in ASIB (including the individuals in Rooker et al., 2019). In some cases, participants’ SIB was also maintained by social reinforcers (see below for additional details). All were diagnosed with autism spectrum disorder and intellectual disability. Findings from the FA and on the operant task (see below) for Participants 1, 2, and 3 were reported in Rooker et al. (2019); however, data on SIB were not reported.

All sessions were conducted in either the living area of an inpatient unit or session rooms, and sessions were conducted one to five times per day. With the exception of select FA conditions, sessions were conducted while the participant and experimenter were seated at a table. Session materials were participant- and condition/component-specific but included leisure items, food, and a microswitch (i.e., a 9 cm by 13 cm button). Standard safety procedures were universally applied to minimize risks to all participants and staff if the need arose within the session (e.g., response blocking, session termination). Additionally, specific protective procedures were in place for some participants. Arm sleeves with splints were used during the FA and operant task for Participants 2 and 7, and the targeted SIB was blocked for Participant 2 during the FA and operant task. For Participant 9, arm sleeves were worn on one arm and a weighted blanket was placed over the legs in the FA but not the operant task. For Participant 6, the targeted SIB was blocked in the FA but not the operant task. As participants were inpatients, they were examined by medical staff daily and following sessions if high rates of SIB were observed; no injuries were incurred as a result of participation.

During the operant task, to minimize the potential effects of prior access to food, sessions were delayed if the participant had eaten within 1–2 hr prior to the start of sessions; no more than 15 min of the conditions in which food was delivered were conducted per day. The operant task (described below) was one part of a larger research protocol that included several other assessments. As such, the operant task was not always conducted immediately following the FA. The average amount of time between the FA and the operant task for eight of the participants was 48.3 days (range, 2–124 days). For Participant 9, the FA interpreted to determine ASIB subtype was from a previous admission; however, data collected at a similar time (approximately 1 month from the operant task) in a similar context (competing stimulus assessment with no interaction control) indicated that the behavior continued to occur in a similar manner.

Data Collection and Interobserver

Agreement—Self-injury was individually defined for each participant (see Table 1), and data on SIB were collected on laptop computers using BDataPro (Bullock et al., 2017). Clinical teams for the inpatient unit collected FA data. Self-restraint was individually defined for each participant (see Table 1) but generally was defined as behavior that limited the ability to engage in SIB (e.g., sitting on hands when the form of SIB was head hitting). The clinical team was comprised of a faculty-level behavior analyst who oversaw the design and management of the FA, as well as extensively trained clinicians who conducted the FA and collected data on SIB. Data on SIB during the operant task were collected over the course of the experiment. These data were collected by trained research assistants. *Switch-pressing* was defined as depressing a microswitch until an audible “click” was heard.

During the FA, two observers independently recorded data during an average of 42.1% of sessions (range, 12.5–62.5%). Proportional agreement coefficients were calculated by subdividing each session into 10-s intervals and dividing the smaller number of responses recorded by the larger number in each interval. The 10-s interval quotients were then averaged and converted to a percentage. Mean agreement during FA sessions for SIB was 94% (range, 81.1–100%) and for self-restraint was 85.9% (range, 50.9–100%). During the operant task two observers independently recorded data during an average of 80% of sessions (range, 50–100%). Mean proportional agreement on SIB during these sessions was 96.9% (range, 89–100%).

Functional Analysis—For all participants, one or more FAs (e.g., Iwata et al., 1982/1994) were conducted to determine the variables that maintained their SIB. To determine subtype, data from the ignore and play conditions of the FA were analyzed. Structured criteria (Hagopian et al., 1997; Roane et al. 2013) were applied to confirm the function of each participant's SIB. Specifically, the FA data presented herein were from the most recent analysis or phase with the strongest design, that had clear and conclusive results regarding the function. For each participant, ASIB was subtyped according to the criteria described by Hagopian et al. (2017), in which responding in the ignore and play condition is further analyzed. Briefly, using the play condition, upper and lower criteria lines were drawn and the data points in the ignore condition below the lower criterion line were subtracted from the number of data points above the upper criterion line. This resultant number was then divided by the number of ignore sessions to produce a quotient score. Next, the subtype of SIB was determined using this quotient score, as well as the guidelines outlined in Hagopian et al. (2017) with respect to SIB and self-restraint. These procedures characterized the degree to which SIB occurred in the ignore and play conditions and the degree to which self-restraint co-occurred with SIB.

During the ignore condition of the FA, the participant and an experimenter were in the room and no programmed consequences occurred. During the play condition of the FA, the participant was provided with a highly preferred leisure item from a clinically conducted preference assessment and experimenter attention (both on a time-based schedule and when solicited by the participant). The occurrence of self-restraint in the FA was relevant for two participants (Participants 6 and 7). Because self-restraint was not blocked in the operant task for these participants, FAs where self-restraint was not blocked were selected to be reported, as they were more directly comparable. Below, only the results of the FA play and no interaction conditions are presented, as these two conditions were used to determine subtype of ASIB.

Operant Task

General Procedures: Procedures were identical to those described in Rooker et al. (2019). First, a paired-stimulus preference assessment identified a highly preferred food to be used as a reinforcer during the operant task. During training and the operant task proper, the participant and two experimenters were present in the room with a table, chairs, a microswitch, and food. The participant was seated at a table across from one experimenter and another experimenter stood to the side (but within arm's reach of the table). The second experimenter's sole task was monitoring the schedule and delivering food when appropriate. The microswitch was on the table in front of the participant, and a container of the participant's preferred food was held by the second experimenter. No programmed consequences were provided contingent on the occurrence of SIB (other than those previously described to ensure safety).

Training: Training was conducted in two to four 5-min sessions, during which switch-pressing produced a small piece of food on a fixed-ratio 1 (FR1) schedule (training data are not presented). Three exposure trials were conducted immediately prior to the first training session. In each exposure trial, the participant was physically prompted to press the microswitch after which a single piece of food was delivered. In training, and across the experiment proper, the microswitch was briefly retracted while the participant accepted the piece of food and until the food was placed past the plane of the lips. This was done to maintain the integrity of the schedules of reinforcement. After these three trials, no other prompts were ever provided. Training was concluded once non-zero, stable rates of switch-pressing were observed across two consecutive 5-min FR1 sessions, after which the operant task was initiated.

Experiment Proper: During the operant task, across two 15-min sessions, two 2-component mixed schedules were implemented. In both mixed schedules, the first component was FR1. The second component in one schedule was a PR schedule; the second component in the other schedule was EXT. Sessions always began with a 5-min FR1 component, followed immediately by a 10-min PR or EXT component (exceptions noted below). These schedules were conducted in a single operant modified reversal design and occurred in a fixed order (FR1|PR, followed by FR1|EXT) for every participant. Each component was terminated based on the passage of time (5 mins for FR1 or 10 mins for PR and EXT). The operant task was complete following exposure to both mixed schedules independent of responding or schedule performance. For Participants 1 and 9, the EXT condition was terminated prior to the end of the fixed 10-min period. This was done because the participants ceased engaging in the operant task for more than 1 min. However, this rule was not used for the other seven participants.

During the FR1 component, each switch-press produced one small piece of food. Immediately following the 5-min FR1 component, the experimenter did not remove the microswitch from the table or otherwise state that the contingency had changed, and the next scheduled component (PR or EXT) began. During the PR component, the ratio of reinforcement increased geometrically (Base 2) following completion of the previous ratio requirement (Stewart, 1975). In other words, each time the participant earned a piece of food, the number of responses required to obtain another piece of food doubled (2, 4, 8, 16, 32, 64, etc.). During the EXT component, switch-pressing did not produce any programmed consequences (i.e., food was present, but never delivered in this condition).

Data Analysis

Functional Analysis.: The level of differentiation in the ignore and play conditions of the FA provides information on the relative sensitivity of SIB to disruption by alternative reinforcement. Percentage differentiation was calculated using data from the FA ignore and play conditions $\left(= 100 - \left[\frac{mean\,SIB\,rate\,in\,play\,Condition}{mean\,SIB\,rate\,in\,the\,Ignore\,Condition} \times 100\right]\right)$. Using this equation, 100% differentiation indicates that no SIB occurred in the play condition, 0% differentiation indicates that the rates of SIB were equal in the play and ignore conditions, and negative percentage differentiation indicates that SIB was higher in the play condition relative to the ignore condition. Rates in the FA conditions were also used to provide a basis for comparing rates of SIB during the operant task as they represent standardized conditions with low (ignore condition) and high levels of alternative reinforcement (play condition).

Operant Task.: To allow for uniform analysis across participants, the proportional change in SIB during the FR, PR, and EXT components of the operant task were also calculated (replacing the mean rate in the FR, PR, and EXT components with that of the play condition in the equation above). In interpreting these results, it was noted when an 80% and 100% reduction in SIB was observed.

A within-session pattern analysis was conducted in two different ways. First, the patterning of SIB during the operant task components was examined relative to the FA play condition. This analysis provides a point of comparison between the two dissimilar procedures for the purpose of examining the disruption of SIB under different contexts and schedule arrangements. These include: (a) noncontingent social interaction and leisure items (in the play condition of the FA) and (b) contingent food reinforcement under reinforcement schedules that engender high rates of responding (FR and PR schedules of the operant task). Since the reinforcement components of the operant task were 20 min in duration (FR1, PR, FR1 = 20 min), a 20-min sample of the play sessions in the FA were obtained. Thus, if each play session was 5 min in duration, four play sessions were selected; if each play condition was 10 min, two play sessions were selected. Play sessions included in this analysis where those in which the rates of SIB were comparable to the median rate of SIB across play sessions. To identify these sessions, we first identified the median rate of SIB across sessions and then selected the two or four sessions closest to this rate. If two sessions had a rate that was equidistant from the median and only one other session was needed for the analysis, the condition with the lower rate was selected, as it was the more conservative option. Second, a within-session analysis was conducted to examine the relation between: (a) reinforcer delivery, (b) switch-pressing, and (c) SIB during each component of the operant task. The purpose of this analysis was to potentially shed light on the mechanisms that might have been responsible for producing changes in SIB.

Results

Participants 1–5 met criteria for Subtype-2 ASIB and Participants 6–9 met criteria for Subtype-3 ASIB based on the procedures described by Hagopian et al. (2017). Table 1 shows the mean rates of SIB in the FA ignore and play conditions for all participants. Although SIB was lower in the play condition relative to the ignore condition for seven of the nine participants, differences were minimal for most participants. As seen in Table 1, for those with Subtype-2 ASIB, the percentage differentiation of SIB in the FA between the ignore and play condition ranged from −12.0% to 26.3% (as a reminder, 100% = no SIB in the play condition, 0% indicates rates of SIB are equal in the play and ignore conditions, and negative values indicate SIB was higher in the play condition relative to the ignore condition). For two participants with Subtype-3 ASIB (Participants 6 and 7), the level of differentiation was higher. However, both engaged in self-restraint almost continuously in the FAs in which these data were obtained. In the remaining two cases (Participants 8 and 9), the percentage differentiation of SIB was 33.3% and 41.8%. In addition to the automatic functions of SIB, an additional function was identified in these FAs for Participant 4 (attention), as well as Participants 8 and 9 (escape from task demands).

Figure 1 (left panels) shows the rates of SIB for each participant during the operant task conditions. The top, left panel shows the rates of SIB during the FR1 and PR components of the operant task. An increase in SIB was observed in the PR condition for six of nine participants, no change was observed for two participants (no SIB occurred), and a decrease in SIB was observed for one participant (Participant 9). The middle, left panel shows the rates of SIB during the FR1 and EXT components of the operant task. An increase in SIB was observed in the EXT condition for four of the nine participants, no change was observed for four participants (no SIB occurred), and a decrease in SIB was observed for one participant. The bottom, left panel shows the rates of SIB during the PR and EXT components of the operant task. An increase in SIB was observed in the EXT condition for two of the nine participants, no change was observed for three participants, and a decrease in SIB was observed for four participants.

Figure 1 (right panels) shows the rates of SIB for each participant during the FA play condition relative to the operant task components to provide a point of comparison to an enriched reinforcement condition that was comparable across all participants. However, these comparisons should be interpreted with caution given the FA and the operant task were different analyses performed at different times. The top, right panel shows the average rate of SIB in the FA play condition relative to the FR1 components of the operant task, which demonstrate relatively lower rates of SIB for all participants while responding during the FR1 components of the operant task. The middle, right panel shows the average rate of SIB in the FA play condition relative to the PR component of the operant task. Rates of SIB were lower for all participants during the PR component. The bottom, right panel shows the average rate of SIB in the FA play relative to the EXT condition. Rates of SIB were lower for seven of the nine participants in the EXT component. Only one of the nine participants (11.1%) was observed to have an 80% reduction in the rate of SIB in the play condition. In contrast, an 80% or greater reduction in the rate of SIB was observed in: (a) the FR1 components of the operant task for seven of nine participants (77.8%), (b) in the PR component of the operant task for six of nine participants (66.7%), and (c) in the EXT component of the operant task for seven of nine participants (77.8%). Further, the complete elimination of SIB (100% reduction in SIB) was never observed in the play condition. However, a 100% reduction in SIB was observed for five participants across both FR1 components, for three participants during the PR component, and for five participants during the EXT components of the operant task.

Figures 2, 3, and 4 depict within-session data during the play condition of the FA (left side of each panel) and during the operant task (right side of each panel). As a reminder, the within-session data from the play condition comes from the two or four play sessions that had the median rate of SIB (see Method). Data are depicted in this manner to easily compare rates of responding between the enriched environment condition of the FA to the reinforcement conditions of the operant task. Figure 2 depicts results for the five participants for whom SIB was eliminated in at least one of the operant task components (FR1 or PR). This occurred more during the FR1 component (Participants 1, 2, 4, and 5) relative to the PR component (Participant 9). Figure 3 depicts results for two participants for whom SIB was decreased (but not eliminated) during the operant task components. Participant 3 appeared to engage in bursts of SIB that occurred near or after the midway point of the FA play condition. In the PR component of the operant task, which was the same length as these conditions, a burst also occurred; however, there were relatively fewer occurrences of SIB. For Participant 8, most FA play sessions were terminated early (not depicted) to prevent injury (the single exception is seen in Figure 3). The patterning of his SIB was characterized by rapid bursts of SIB necessitating session termination. Comparatively, the operant task never had to be terminated due to high-rate SIB. Figure 4 depicts results with cases where self-restraint was affected during the operant task. Two participants with Subtype-3 SIB engaged in high levels of self-restraint in the FA play condition. Based on the duration of time engaged in self-restraint and the duration of FA play condition sessions, the mean percentage of session time engaged in self-restraint was 100% of session for Participant 6 and 85.2% of session for Participant 7 (only the median play conditions are depicted in Figure 4). As such, these participants had comparatively lower levels of SIB in the FA play condition. However, for both participants some of the operant task conditions were associated with no SIB and no self-restraint (i.e., 0% of session).

Figures 5 and 6 depict cumulative SIB and switch-pressing, and reinforcer delivery for the purpose of examining how SIB changed as a function of concurrent switch-pressing and the varying schedules of reinforcement. Figure 5 shows data from participants for whom the findings would suggest reductions in SIB occurred as a function of response competition or reinforcer competition. For Participants 1, 6, 7, and 9 (top four panels), SIB was either eliminated or markedly reduced while switch-pressing was occurring, even when reinforcement was reduced (PR) or not available (EXT). These findings might suggest it was not the delivery of reinforcement that competed with reinforcement maintaining SIB (reinforcer competition), but that engagement in switch-pressing may have competed with engagement in SIB (response competition). For Participant 1, although three instances of SIB did occur in the PR phase, no SIB occurred in the EXT phase, thus we concluded this participant’s responding was more similar to Participants 6, 7, and 9. In contrast, for Participant 4 (bottom panel), SIB was eliminated when reinforcement was dense (FR1) but reliably occurred when the reinforcement was reduced (PR) or not available (EXT), even though switch-pressing was occurring. These findings would suggest the reductions in SIB were due to reinforcer competition.

Figure 6 shows data from participants for whom the response patterns were mixed and equivocal with respect to implicating response or reinforcer competition. Although Participants 2, 3, 5, and 8 (bottom four panels) showed reductions of SIB in some components of the operant task, no clear patterns were replicated making it difficult to speculate on what mechanisms may have been responsible for reductions in SIB. Participant 2 engaged in low rates of switch-pressing and no SIB in the EXT component, this makes it difficult to speculate what mechanism might be responsible for reductions in SIB in some phases of the operant task. Participant 5 showed marked reductions in SIB during the operant task (relative to the play condition of the FA, Figure 2); however, differences across components of the operant task were marginal. The SIB of Participants 3 and 8 was reduced the least among all the participants (see Figures 1 and 3) relative to the play condition of the FA SIB. For these participants, SIB was lower during the FR1 and PR components of the operant task but higher in the EXT component.

Discussion

Previous research has suggested that sensitivity of SIB to disruption by alternative reinforcement and the presence of self-restraint are critical features of automatically maintained SIB. These characteristics are evident in FAs and later in treatment. Subtypes 2 and 3, which show diminished sensitivity to disruption are more likely to not be sufficiently reduced with treatment using reinforcement alone, often necessitating the use of protective equipment, response blocking, and restraint (Hagopian et al., 2015, 2017). Subsequent research provided preliminary evidence that, for individuals with Subtype-2 ASIB, the relative insensitivity may be specific to that behavior, rather than a generalized response tendency of the individual (Rooker et al., 2019). The current study showed that when participants with Subtype-2 or -3 ASIB performed an operant task under schedules that engendered a high rate of responding to produce food reinforcement, SIB was reduced in all cases, and eliminated in some.

The operant task contained the following elements: (a) contingent food reinforcement, (b) a discrete motoric operant response, and (c) a schedule of reinforcement that engendered high rate responding. Reductions in SIB could have been due to response competition, reinforcer competition, or both. A response competition mechanism could be inferred if rates of SIB varied inversely with the rates of switch-pressing (i.e., if SIB was lower when switch-pressing was higher, and if SIB was higher when rates of switch-pressing were lower). This pattern suggests that engagement in switch-pressing somehow interfered with engagement in SIB. In contrast, a reinforcer competition mechanism could be inferred if rates of SIB varied inversely with the density of reinforcement (i.e., if SIB was lower when the density of reinforcement was higher, and if SIB was higher when the density of reinforcement was lower). This pattern suggests that reinforcement produced by switch-pressing attenuated the motivating operation for the reinforcement maintaining ASIB. Although the design of this study does not permit definitive conclusions about these mechanisms, analysis of within-session patterns of responding provides some basis for speculation.

Four participants' SIB (Participants 1, 6, 7, and 9) remained low whenever switch-pressing occurred at high rates, even when reinforcement was delivered at a lower density (PR) or not provided (EXT), which suggests response competition may be the mechanism for the observed effect in these cases. Although switch-pressing was not fully incompatible with SIB, the findings indicate when switch-pressing was occurring at high rates, SIB was relatively low – suggesting some type of response competition. For example, it may be the case that it was difficult to engage in SIB and simultaneously engage in switch-pressing or that it was more effortful to alternate between switch-pressing and SIB. Switch-pressing required a different set of motoric responses, and thus the individual would need to reorient to engage in SIB, which could be conceptualized as a handling cost (e.g., DeLeon et al., 2014; Haddock et al., in press). Alternatively, for one participant (Participant 4), SIB was markedly reduced only when the density of reinforcement was high (during FR components), and SIB increased when reinforcement was diminished (during PR and EXT components), which suggests reinforcer competition may have been responsible for reductions in SIB in this case. For the remaining participants (Participants 2, 3, 5, and 8), the patterning of SIB across the components of the operant task were mixed with respect to the relation between the density of reinforcement, rates of switch-pressing, and the rates of SIB. Although reductions in SIB were observed, it is difficult to determine whether those effects were due to response or reinforcer competition.

Although analysis of these patterns of responding allows for some speculation, the extent to which response competition and/or reinforcer competition were responsible for reductions in SIB would better be determined via an experimental analysis. Specifically, the use of a noncontingent food condition (in which switch-pressing was not occurring) yoked to the rate of reinforcement in the contingent reinforcement condition would be a relevant condition to include in future analyses. If SIB is comparably low under the yoked noncontingent food condition relative to the contingent reinforcement condition, then this would indicate that reductions in SIB were due to reinforcer competition. However, if SIB is high under the yoked noncontingent food condition relative to the contingent reinforcement and extinction conditions, then this would indicate that response competition was responsible for the reductions in SIB. In addition to identifying the mechanism(s) of this effect, examining the durability of these effects is equally important. That is, the current analysis suggests the effects of these mechanisms on ASIB, but only in a very brief exposure to an alternative contingency with a very dense schedule of reinforcement. Thus, in addition to showing the reliability of this effect, the degree to which the effect persists when exposed to leaner schedules of reinforcement implemented over temporally extended periods should also be investigated.

In examining the differences in the rates of SIB between FA play conditions and the operant task, it is also important to note that there were differences between the types of alternative reinforcement available across those conditions. The toy included in the play condition of the FA, and the food used in the operant task were both identified through a preference assessment, but only the food was empirically validated as a reinforcer through the training for the operant task. However, anecdotally, interaction with toys was common in the play condition (see below for why these data are not presented). Additionally, it is possible that there are inherent differences between these classes of reinforcers (food versus social and toys). That is, food as a dissimilar stimulus class may have had more inelastic demand in these conditions than demand for the reinforcer maintaining SIB (Deleon et al., 2013). That is, the experiment itself may have set up contrasting economies for preferred foods (relatively low effort to obtain inside the experiment, and potentially requiring substantial effort to obtain outside the experiment) and SIB (equally easy to obtain inside and outside the experiment), such that engaging in SIB in the experiment was punished by opportunity cost (Hursh et al., 2013).

Finally, although the operant task described in the current study should not be conceptualized as treatment (i.e., effects were demonstrated briefly, over a very short period), there are some similarities between this procedure and a differential reinforcement of alternative behavior (DRA) treatment. That is, the procedure describe in this study is similar to an intervention wherein ASIB might be treated by arranging for high-preference reinforcement for engaging in an alternate activity that might compete with SIB. This type of treatment of ASIB has rarely been investigated.

Based on the literature review conducted by Rooker et al. (2018), it is clear that there is much more available research on the effectiveness of noncontingent reinforcement (NCR) than DRA as a treatment for ASIB. The review found that DRA was only attempted six times in the absence of NCR (including three cases where DRA was combined with differential reinforcement of other behavior), whereas NCR was attempted 37 times in the absence of DRA. Also, in most published cases where DRA had been attempted, the target-alternative response produced access to preferred leisure items or activities rather than foods (e.g., Dozier et al., 2007; Hanley et al., 2000 Ringdahl et al., 1997). The use of food as reinforcers within a DRA intervention to treat ASIB is described in only two studies (Lindberg et al., 1999; Scheithauer et al., 2017). However, there is reason to suspect that the schedule of reinforcement did not sufficiently compete with ASIB in these studies. Previous research has demonstrated that children with intellectual and developmental disabilities may prefer foods and liquids to activities/leisure items (Bojack & Carr, 1999; Conine & Vollmer, 2019; DeLeon et al., 1997; Fahmie et al., 2015). Thus, because preference assessments are often predictive of reinforcer efficacy (e.g., DeLeon et al., 1996), there is some basis for using edibles (rather than leisure items) to reinforce an alternative response to increase the potency of DRA as a treatment for ASIB. Speculating about how this might be used in the treatment of ASIB, one might noncontingently provide toys and contingently provide food for a specific action with those toys. Similarly, arranging multiple noncontingent and contingent competing events in a single condition (area for toy play, area for work that produces food) might also be an effective treatment. Research to date has yet to evaluate the potential utility of these treatments. However, these findings suggest it may be worthwhile to further explore the use of DRA as a treatment component for ASIB in some situations.

The current study is not without limitations. Although the comparison of rates of SIB during the operant task relative to the play and no-interaction conditions of the FA provided a basis for comparison, it would have been better to have a baseline condition within the operant task. This condition would establish if switch-pressing would occur in the absence of programmed contingencies. Thus, it is not possible to rule out that switch-pressing was maintained by automatic reinforcement for all participants. Furthermore, that switch-pressing continued to occur in the EXT condition (for 77.8% of participants) would seem to support the idea that switch-pressing was being maintained by automatic reinforcement for some participants. However, even for participants for whom switch-pressing occurred in EXT, there was generally a change in the rate across reinforcement and extinction conditions, which would support the notion that switch-pressing was maintained by social contingencies (i.e., food reinforcement), mitigating this limitation to some degree. Data on engagement with toys and the experimenter in the FA play condition may have contributed to the analysis of the possible mechanisms involved. These data may have allowed for a within-session analysis of the patterns of behavior, similar to that conducted for the operant task (Figures 5 and 6), and thus could have provided additional information on the degree to which engagement with those stimuli competed with SIB. These data are not presented because uniform definitions of engagement/interaction with toys were not present across FAs (i.e., definitions and targets were individualized). Additionally, reinforcer consumption time was not removed from the operant task sessions. However, this limitation is slightly mitigated by the relatively brief amount of time the operant task was restricted while consumption was occurring.

Finally, there were slight differences in the patterns of SIB and the procedure across participants, which limit the findings. As described in the results, interesting patterns of SIB were observed that might have been further investigated in a more extended analysis. For example, the pattern showing bursts of SIB occurring midway in sessions for Participant 4 was interesting, and further pattern analysis for individuals with ASIB should be an area for future research. For two participants with Subtype-3 ASIB, the data selected for comparison in the FA contained co-occurring self-restraint. This is because these data were used to determine subtype. In addition, for two participants the criterion for terminating the EXT component of the operant task was the absence of responding, a criterion not used for other participants. Despite these limitations, findings of the current study suggest there are some conditions in which the SIB of individuals with Subtype-2 and -3 ASIB (and self-restraint in Subtype 3) can be markedly disrupted with alternative reinforcement – at least temporarily. These findings also suggest that further study on the use of DRA schedules, as well as edible reinforcers, in the treatment of ASIB is warranted. Although the current findings should be considered preliminary, they raise questions that can be examined further in translational studies, and point to some potential tactics that could be explored for improving the efficacy of interventions for these treatment-resistant behaviors.

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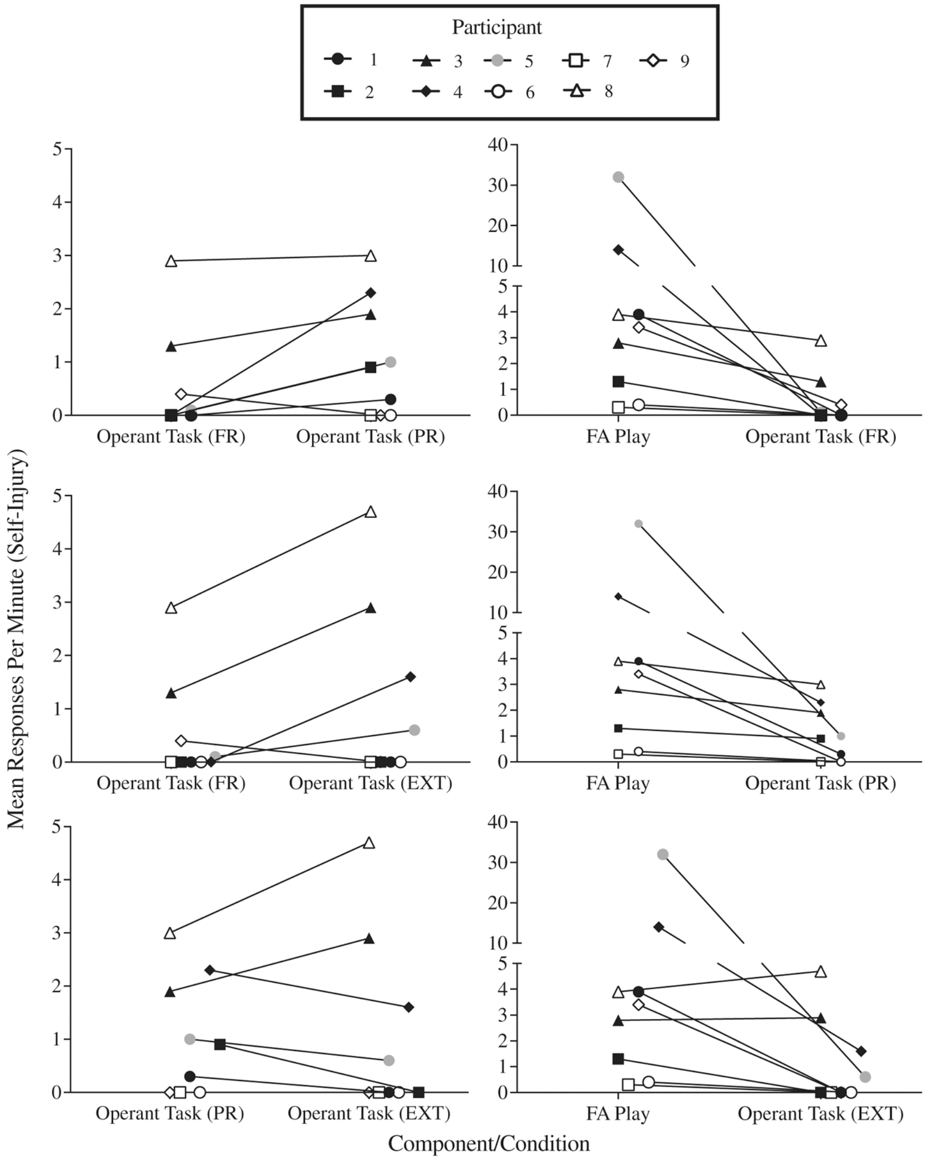

Figure 1. Mean SIB in the FA Play Condition and Operant Task

Note. FR = fixed ratio 1, PR = progressive ratio, EXT = extinction, FA = Functional Analysis.

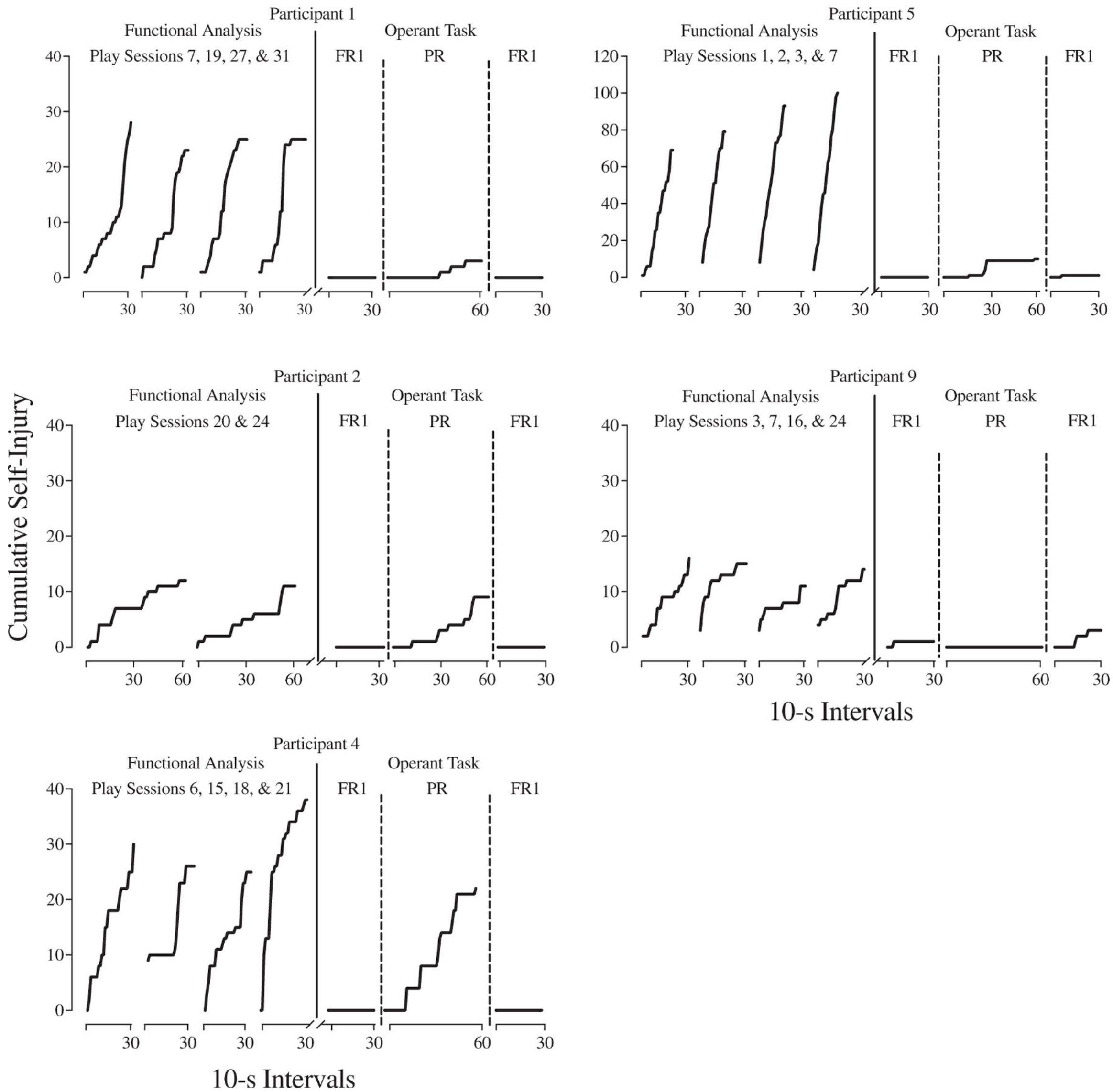

Figure 2. Within Session Patterns of SIB

Note. FR1= fixed ratio 1, PR = progressive ratio. Data depicts those participants for which no SIB was observed in at least one operant-task condition in the FA play and operant task conditions.

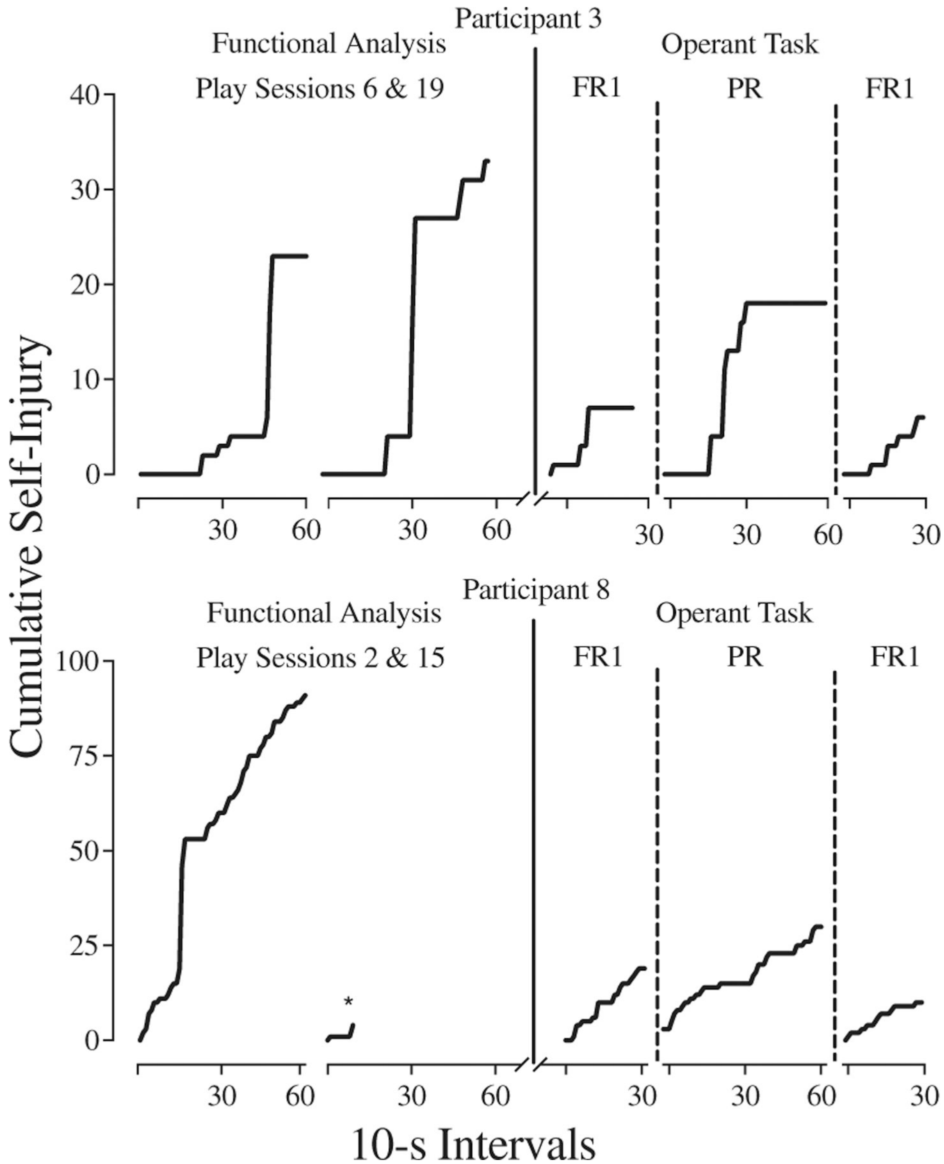

Figure 3. Within Session Patterns of SIB

Note. FR1= fixed ratio 1, PR = progressive ratio. Asterisk indicates when a session was terminated to prevent injury. Data depicts those participants for which SIB was never completely suppressed in at least one operant task condition.

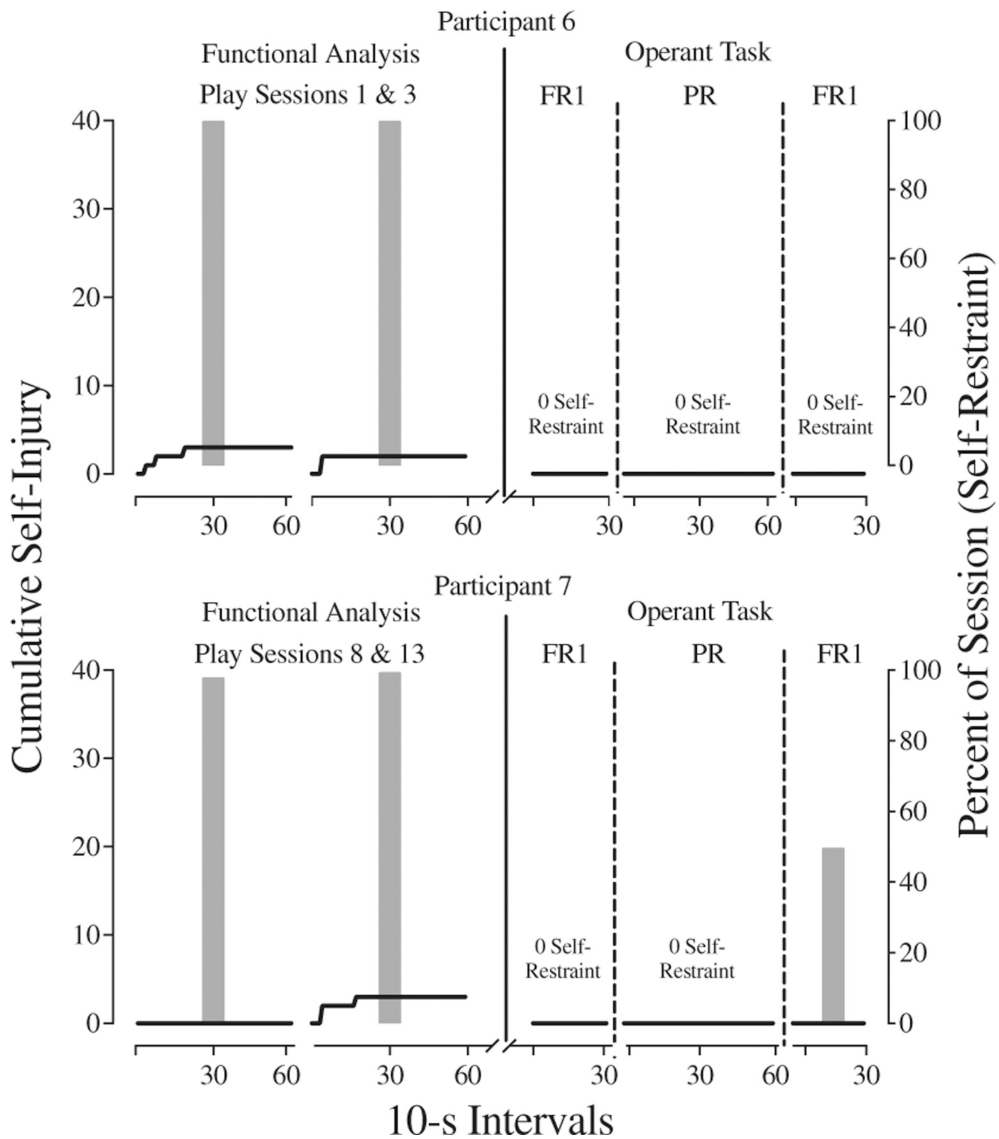

Figure 4. Within Session Pattern of SIB and Percentage of Session with Self-Restraint

Note. FR1= fixed ratio 1, PR = progressive ratio. Data depicts those participants in the FA and operant task conditions for which self-restraint occurred frequently in the operant task condition.

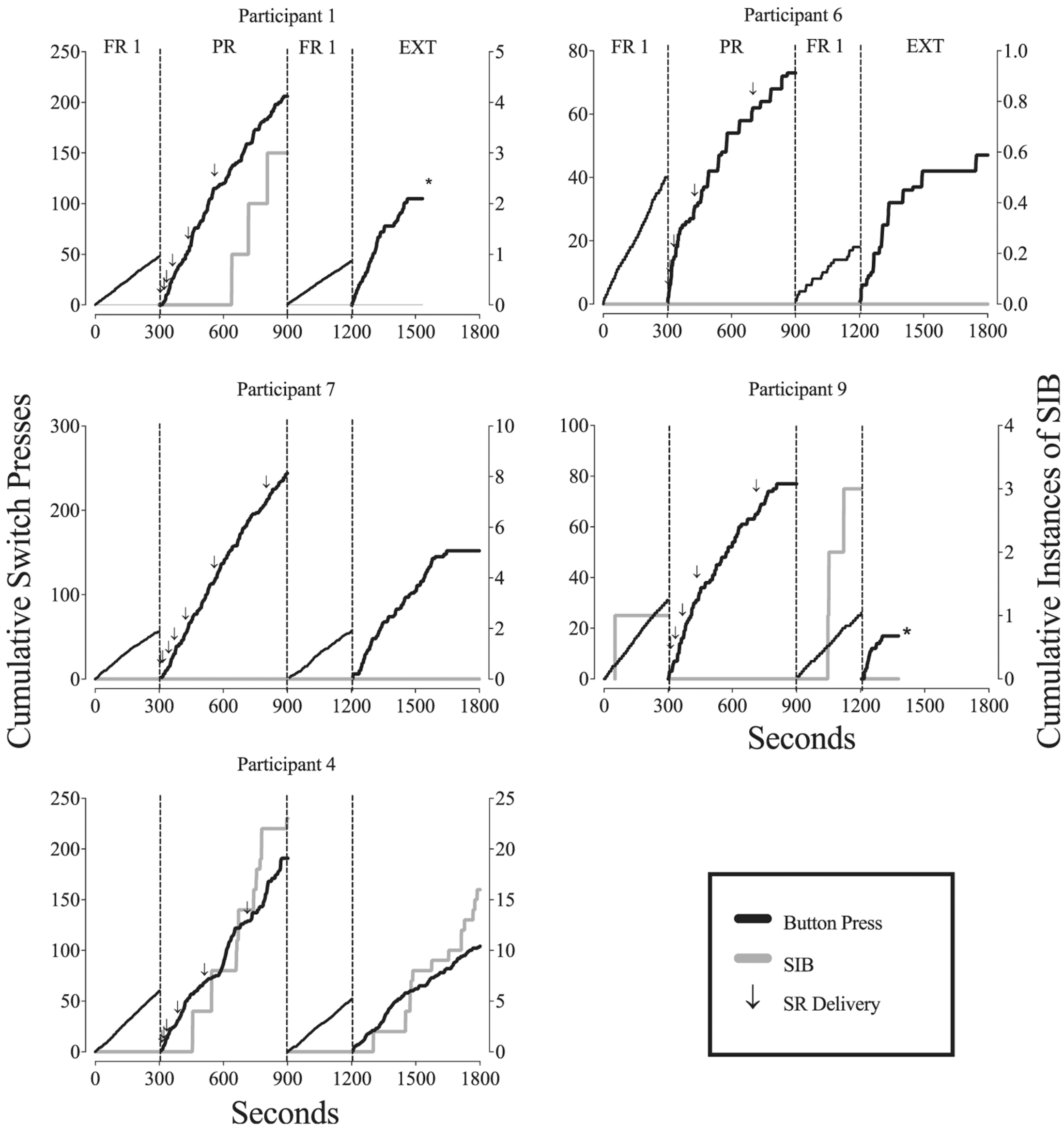

Figure 5. Within Session Patterns during the Operant Task

Note. FR1= fixed ratio 1, PR = progressive ratio, EXT = extinction. Asterisks indicate when a session was terminated due to nonresponding. Reinforcement delivery not depicted in the FR1. Data depicts participants for which response competition (top four panels) and reinforcer competition (bottom panel) appeared to be the mechanism of the effect.

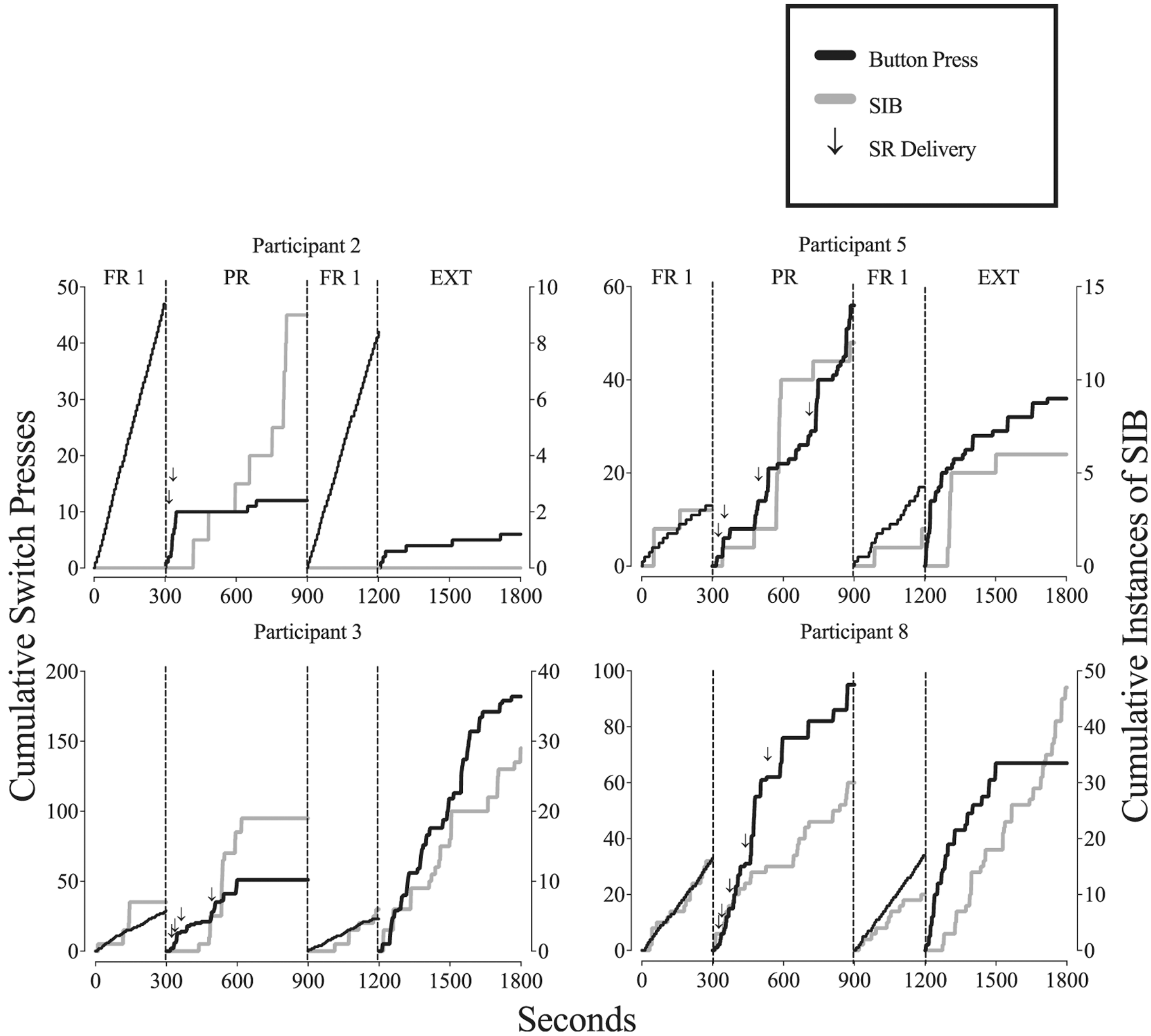

Figure 6. Within Session Patterns during the Operant Task

Note. FR1= fixed ratio 1, PR = progressive ratio, EXT = extinction. Reinforcement delivery not depicted in the FR1. Data depicts participants for which a mechanism could not be identified.

Table 1

Demographics, Topographies of Self-Injury and Self-Restraint, and FA data

Participant, Subtype	Sex, Age	Topographies of SIB	Topographies of Self-Restraint	Functional Analysis: Percentage Differentiation	Functional Analysis: Ignore Condition	Functional Analysis: Play Condition
1, 2	M, 20	Biting; head-to-surface (head banging); hand-to-head		13.3	4.5	3.9
2, 2	M, 13	Picking; scratching; digging; rubbing		−8.3	1.2	1.3
3, 2	M, 9	Scratching; picking		−12.0	2.5	2.8
4, 2	F, 11	Hand/knee to head/face		26.3	19.0	14.0
5, 2	M, 11	Hand/object to head		13.0	36.8	32.0
6, 3	M, 12	Hand/arm/object to head; biting; scratching; pinching; kicking; body hitting	Limiting hand movement using clothing, furniture, or other body parts (clasping hands, placing hands between legs, laying on arms or hands)	85.7	2.8	0.4
7, 3	M, 13	Biting; scratching; pinching; kicking; hitting surfaces; tongue/lip biting	Limiting hand movement using clothing, furniture, or other body parts (Sitting on hands placing hands, between legs, laying on arms or hands)	75	1.2	0.3
8, 3	M, 14	Hand/shoulder/arm/object/knee to head; chin pressing; hand/arm/object to body; scratching; pinching; kicking; tongue/lip biting; body to surface	Limiting hand movement using clothing, other individuals, or other body parts (clasping hands)	41.8	6.7	2.9
9, 3	F, 17	Hand/object/knee/shoulder to body; head bang	Limiting hand and leg movement using body parts (pressing a fist down with the other hand, clasping hands, sitting or lying on arms or hands, placing hands between legs, wrapping arms around torso or head or over each other, locking legs together, kneeling and sitting on heels, pressing feet or ankles against the side of a chair)	33.3	5.1	3.4

Note. *SIB* = self-injurious behavior. Percentage Differentiation refers to the proportional difference in responding in the ignore condition relative to the play condition of the functional analysis; this is expressed as a percentage (see text). Values listed under Ignore and Play Conditions refer to the mean responses per minute of SIB.