Title Page

Behavioral Treatment of Self-Injury: 2001 to 2016

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Behavioral Treatment of Self-Injury: 2001 to 2016

Abstract

Individuals diagnosed with intellectual and developmental disabilities (IDD) frequently exhibit self-injurious behavior (SIB). Kahng, Iwata, and Lewin (2002ab) reviewed published behavioral treatments of SIB from 1964-2000. Results suggested that behavioral treatments were highly efficacious at decreasing SIB, particularly when based on the results of a functional assessment. The purpose of this paper is to update, replicate, and extend the previous review. The current findings indicate an increase in studies reporting automatically maintained SIB as well as less efficacious treatments overall. Discussion of our conclusions and methods of SIB assessment and treatment are discussed, both as they relate to the previous review and for future directions.

Keywords: Self-injury, SIB, developmental disabilities, treatment review

Behavioral Treatment of Self-Injury: 2001 to 2016

Self-injurious behavior (SIB) refers to a class of behavior, which results in physical harm for the individual (Tate & Baroff, 1966). The resulting injury often comes in the form of tissue damage, such as contusions or abrasions (Iwata, Pace, Kissel, Nau, & Farber, 1990; Hyman, Fisher, Mercugliano, & Cataldo, 1990). However, other types of damage can result from SIB as well, including fractures, physical deformities, detached retina or blindness, and in extremely severe cases, death (Minshawi et al., 2014).

SIB is a class of behavior that is often associated with intellectual and developmental disabilities (IDD). The prevalence of SIB among that population has been estimated between 5-41% of individuals (Cooper et al., 2009), with common averages reported at 27.7% of individuals diagnosed with autism spectrum disorder (ASD; Soke et al., 2016). A significant amount of behavior analytic research has focused on SIB assessment and treatment due to the detrimental effects on a variety of aspects of the daily lives of individuals who engage in this behavior. These aspects include the potential for injury, distress for family members, and the requirement for more restrictive settings and procedures (Oliver, Murphy, & Corbett, 1987; Cooper et al., 2009). Effective SIB treatment is required in order to mitigate potentially harmful health risks including recurrent infections and severe injuries that can have lasting implications for the individual and other stakeholders (Minshawi et al., 2014).

Research has documented many different topographies of SIB such as hitting one's body parts against fixed objects, biting, hitting, or kicking the body or head, hand mouthing, pica, pinching, poking the ears or the eyes, hair pulling, scratching, or self-restraint (Iwata, Pace, et al., 1994). Previous research has demonstrated that SIB can be maintained by both socially mediated reinforcement (Iwata, Duncan, Zarcone, Lerman, & Shore, 1994; Iwata, Dorsey, Slifer, Bauman,

& Richman, 1982/1994; Iwata, Pace, et al., 1994), as well as automatic reinforcement (Piazza, Adelinis, Hanley, Goh, & Delia, 2000; Vollmer, 1994). Previous research has documented SIB behavioral treatment efficacy in a number of different settings, from well controlled hospital settings (Hagopian & Adelinis, 2001; Kuhn, Chirighin, & Zelenka, 2010; Jennett, Jann, & Hagopian, 2011; Kahng, Abt, & Wilder, 2001), to more naturalistic environments such as home (Garcia, Starin, & Churchill, 2001; Barnoy, Najdowski, Tarbox, Wilke, Nollet, & Roane, 2009; Anderson & McMillan, 2001), or school settings (Vorndran & Lerman, 2006; Hoch, McComas, Thompson, & Paone, 2002; Richman, Lindauer, Crosland, McKerchar, & Morse, 2001).

Given the variety of SIB forms and features, there are several different theoretical hypotheses about the etiology of the behavior that have led to different treatments. The two dominant perspectives are the biomedical and behavior analytic models. Each differ in their conceptual framework, with the biomedical model leading to pharmacological treatments and the behavioral model leading to behavioral treatments. The biomedical theory views that engaging in SIB produces specific biochemical reactions, such as endorphins or hormones, which act as maintaining variables for the problem behavior. By contrast, a significant literature base focuses on SIB treatment using a behavior analytic model. These behavioral treatments have proven highly efficacious in SIB reduction; therefore, warranting considerable attention (e.g., Kahng et al., 2002ab; Rooker, Bonner, Dillon, & Zarcone, 2018).

The behavior analytic model proposes that the etiology of this class of problem behavior is based on socially mediated or automatically reinforcing contingencies (i.e., learned behaviors). Based on the individual's history of reinforcement, different environmental variables such as attention (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993), escape (Barrera, Violo, & Graver, 2007), or access to tangibles (Hagopian, Wilson, & Wilder, 2001) may maintain SIB.

Automatic reinforcement may also act as a maintaining variable for SIB; however, it can be difficult to determine the exact variables maintaining this type of behavior (Piazza et al., 2000; Vollmer, 1994). As we are primarily focusing on replicating and extending the prior behavioral assessment and treatment review, it is beyond the scope of this paper to provide a detailed account of the different conceptual models (for accounts of the various conceptual models and different perspectives, see Schroeder, Oster-Granite, & Thompson, 2002).

A functional assessment (i.e., functional behavioral assessment) is a process that has allowed for the identification of variables influencing problem behaviors (Iwata et al., 1982/1994; Hanley, 2012). Consequently, the functional assessment of SIB has led to efficient and efficacious treatment outcomes (e.g., Kahng et al., 2002b). Function-based treatment allows for relationships to be identified between the problem behavior and the reinforcing contingencies maintaining that behavior. Moreover, with the advent of functional assessment technology, there has been a steady increase in the number of interventions utilizing reinforcement-based procedures, rather than default technologies (Kahng et al., 2002ab). Thus, in order to find effective SIB treatments, it is important to determine the maintaining variables, and effectively manipulate those variables through behavior intervention.

To date, there have been several SIB treatment reviews across various diagnoses (e.g., ASD, IDD), ages, and types of interventions (e.g., behavioral, medical) (e.g. Kahng et al., 2002ab; Prangnell, 2009; Rooker et al., 2018; Morano et al., 2017). Most relatedly, Kahng et al. (2002ab) reviewed the published literature regarding the behavioral treatment of SIB from 1964-2000. They compiled data on participant demographics, SIB topographies, treatment setting, interobserver agreement, experimental design, type of functional assessment and treatment, treatment effectiveness, follow up and generalization, as well as SIB function(s). Kahng et al.

(2002a) reported a steady increase in the number of studies investigating treatment of SIB; however, the majority of studies contained a relatively small number of participants or consisted of case studies. Most commonly, participants were diagnosed with an intellectual disability (71.2%) and about a quarter of the participants engaged in multiple SIB topographies (27.6%). Kahng et al. (2002ab) reported that reinforcement procedures were more likely to be used than punishment procedures, although reinforcement interventions were the only treatment that did not achieve at least an 80% reduction in SIB when implemented alone. Most other treatments (e.g., antecedent manipulations, extinction, response block, mechanical restraint) reviewed by Kahng et al. (2002a) reduced SIB by at least 80% when utilized alone or combined with other interventions. However, the overall level of treatment effectiveness did not increase consistently over the years (Figure 3). Kahng et al. (2002b) concluded that there was a continued need for well controlled SIB studies following a functional assessment, especially in the context of automatic reinforcement, considering the potential difficulty in treating it when it is maintained by variables which are difficult to identify and control (Hagopian, Rooker, & Zarcone, 2015; Hagopian, Rooker, Zarcone, Bonner, & Arevalo, 2017). Therefore, the authors also recommended a focus on prevention so that establishing operations can be manipulated to prevent the likelihood of SIB acquiring reinforcing properties (Kahng et al., 2002a). Since this review, there has not been an update on the progress of SIB behavioral treatments.

Therefore, the purpose of the current review is to contribute to the SIB treatment literature by replicating and extending Kahng et al. (2002ab). The present study reviewed the SIB literature from 2001-2016, replicating the search in the same journals as Kahng et al. (2002a) and including 15 additional journals. This review also added several independent variables evaluating further characteristics of SIB topographies and updated measures of

treatment efficacy. Finally, behavioral treatments were evaluated as to complete SIB suppression, as it relates to the severity and injury caused by it. Additional evaluation into treatment generality, maintenance, integrity, and social validity are assessed.

Method

The literature search was conducted similarly to Kahng et al. (2002ab). Kahng et al. (2002ab) reviewed the literature from 1964-2000, while the current literature review searched articles published from January 2001 through September 2016. In some cases, we had to manually exclude articles that were published from October-December 2016. We searched the following terms on each journal's home page, under "all fields": "self injury," or "self-injurious behavior," or "SIB" for 68 journals as well as the PubMed website. We only included studies published in English. The 61 journals included in the Kahng et al.(2002ab) reviews were searched in addition to 7 new journals that did not exist at the time (e.g., *Behavior Analysis in Practice, Developmental Neurorehabilitation*). Some of the originally reviewed journals were no longer in publication at the time of this review (e.g., *Behavioral Engineering*). Ancestral searches were not completed.

The inclusion and exclusion criteria were the same as those described by Kahng et al. (2002ab). Specifically, the article needed to include: (a) data on SIB behavioral treatments, (b) individuals diagnosed with IDD, (c) the use of a single-case experimental design (Kazdin, 2011), and (d) individual, repeated measures of SIB data without including other topographies of problem behavior (i.e., data in which SIB and aggression were both combined and reported under a broad definition of problem behavior were excluded). Studies were excluded if articles (a) featured assessment only, (b) included pharmacological treatments alone or in conjunction

with behavioral treatments, (c) used large *N* designs that did not report individual data, and/or (d) did not isolate SIB as a dependent variable.

We reviewed each abstract and/or title for inclusion in the review. If the information was not clear based on the abstract alone, we saved the article for further review. Once the final number of articles was determined, four reviewers categorized each article by the following variables and all data were coded per participant:

Demographic Characteristics

Participants. All demographic information collected were identical to the Kahng et al. (2002a) review. Data were collected on participants' gender, age, and up to six different diagnoses including IDD and other diagnoses (e.g., ASD, Down syndrome, cerebral palsy). Participants were divided into four age groups: (a) 0-10 years old, (b) 11-18 years old, (c) 19 and over, or (d) no data. Data were also reported on the level of IDD and were divided into five groups: (a) mild, (b) moderate, (c) severe/ profound, (d) no data (level not specified), or (e) none.

Treatment Setting. Information regarding the treatment setting(s) as described by Kahng et al. (2002a) were recorded. The settings consisted of 10 options: (a) clinic, (b) day care, (c) group home, (d) home, (e) hospital, (f) institution, (g) school, (h) workshop, (i) other, or (j) not listed.

Topographies of SIB. As described in Kahng et al. (2002a), the topographies of SIB were categorized as: (a) bruxism, (b) head banging/ hitting, (c) biting, (d) hand mouthing, (e) body hitting, (f) pica, (g) vomiting/ rumination, (h) scratching, (i) hair pulling, (j) eye poking, (k) skin picking, (l) pinching, (m) kicking, (n) other, and/or (o) no data (information). Behaviors could be listed from one to six different topographies. If more were reported, the first six listed

topographies were reported. Topographies that were not listed from the original Kahng et al. (2000a) review were reported as "other."

Severity/Intensity of SIB. The severity and/or intensity of the SIB were evaluated to differentiate from potential repetitive or stereotypical types of SIB. Types of SIB severity and intensity were reported if the authors indicated a level of harm (mild, moderate, severe, life threatening), with or without a formal severity assessment. These data were only noted if the authors explicitly stated it (e.g., Johnny engaged in severe head banging). If the data were not reported or were unclear, the option "no data" were selected.

All studies were reviewed for a reported SIB history and tissue damage. These data were only considered if it was specifically stated within the study (e.g. a specific number of years since the onset of SIB, "injury resulting in tissue damage"). If there were no direct descriptions of history or tissue damage, "no data" or "not listed" were selected.

We were also interested in measuring whether or not studies provided objective accounts of the severity of the behavior. One tool for objectively assessing injury severity is the SIT scale (Iwata et al., 1990), which allows raters to objectively measures severity or size of injury or trauma. Therefore, we collected data on how often the SIT scale was used to measure behavior severity.

Procedures

Interobserver Agreement (IOA). As in Kahng et al. (2002a), each study was reviewed for whether or not they reported IOA statistics. If the study had a second rater independently observe and score agreement and non-agreement of behavior(s), then IOA were counted as having been assessed.

Experimental Design. Identical to the procedures outlined by Kahng et al. (2002a), studies were reviewed for use of a single-case experimental design (Kazdin, 2011) with replication for SIB treatment. Examples included the use of a: (a) reversal design, (b) alternating treatments design, (c) multielement design, (d) multiple baseline design, and/ or (e) changing-criterion design. Any study that did not include a baseline or demonstrate experimental control through replication (e.g., AB designs) were non-experimental designs.

Treatment

Type of Treatment. Treatments were categorized as in the Kahng et al. (2002ab) reviews across eight different domains with various subtypes for both reinforcement and punishment. The eight domains included: (a) reinforcement, (b) punishment, (c) extinction, (d) mechanical restraint, (e) antecedent manipulation, (f) response blocking, (g) antecedent exercise and (h) other. Response blocking was considered its own category as it has been previously discussed as punishment (Lerman & Iwata, 1996) or extinction (Smith, Russo, & Le, 1999). Within the category of reinforcement, subtypes included: (a) differential reinforcement of other behavior (DRO), (b) differential reinforcement of alternative behavior (DRA), and (c) noncontingent reinforcement (NCR). Punishment included 13 subtypes (e.g., response cost, overcorrection, and protective equipment). If a multiple component treatment plan (one or more treatments) was utilized, each component of the treatment plan was included separately, but the use of a treatment package was also reported.

Efficacy. The efficacy of each treatment was compared to the most recent baseline level. The data from each treatment were obtained using a data extraction program, WebPlotDigitizer™ (Rohatgi, 2016). This program has been determined to be the most accurate (Moyaert, Maggin, & Verkuilen, 2016). Each graph was copied and saved as a jpeg then

uploaded into the WebPlotDigitizer ™ website. As conducted in Kahng et al. (2002a), up to five data points across the most recent baseline and each most recent treatment phase were extracted. If either phase consisted of less than five data points, the maximum number of data points that would allow for an equal calculation were utilized (e.g., three from baseline, and three from treatment). Once extracted, the raw data were calculated in terms of efficacy using the same equation from Kahng et al. (2002ab). An efficacy percentage was determined by taking the mean of treatment subtracted from the mean of baseline, divided by the mean of baseline, and multiplied by 100 (e.g.,79%). Percentages closer to 100% indicated stronger efficacy, whereas, percentages closer to or less than 0% indicated low or no efficacy.

Identical to Kahng et al. (2000a), we also evaluated the mean percentage of SIB reduction as compared to baseline, for each major treatment category in relation to the use of a functional assessment. Specifically, this included the treatment(s) being implemented alone, or in conjunction with another intervention. For example, we examined the overall efficacy of antecedent interventions when implemented alone, and in combination with other interventions (e.g., extinction, punishment), when a functional assessment was and was not completed. This allowed for the comparison of different combinations of treatment efficacies, with and without functional assessments.

Complete Suppression. In order to further evaluate treatment efficacy, the complete SIB suppression for each treatment was evaluated. Complete suppression was defined as 0 rates of SIB or 0% for a minimum of the final three consecutive sessions for each intervention. This criterion was arbitrarily chosen as it was considered an ideal and conservative definition of elimination for this type of problem behavior.

Functionally Equivalent Replacement Behavior (FERB). For each participant, studies were reviewed as to whether a FERB was taught. A FERB includes responses that are under control of the same antecedent stimuli and consequences as the problem behavior (Horner & Day, 1991). For automatically maintained SIB, the exact reinforcing component had to be identified and replaced with a behavior that provided the same sensory stimulation. For example, for hand- to-head hitting, the authors had to demonstrate it was the vibratory stimulation provided to the head that was the reinforcer. Subsequently, they would teach participants a replacement behavior to access a similar vibratory stimulation. If this specific reinforcer was not identified, a FERB was not reported.

Follow-up and Generalization. Each treatment was reviewed for the inclusion of maintenance and generalization effects. If conducted, the duration of maintenance effects was noted, as well as all generalization types (e.g., settings, people).

Treatment Integrity and Social Validity. Each study was reviewed for the inclusion of treatment integrity. Articles were also reviewed for the inclusion of social validity measures by participants, stakeholders, or caregivers.

Interobserver Agreement (IOA)

A second reviewer independently assessed 21.3% of the articles (18% of the data sets). Excluding the treatment efficacy category, agreement percentages were calculated using the exact method in which each selection within each category was compared (e.g., topography, treatment). An agreement was defined as both reviewers selecting the exact same response. A disagreement included one reviewer selecting one response (e.g., skin picking) and the second reviewer selecting a different response (e.g., slapping). The total number of agreements was divided by the total number of agreements plus disagreements and multiplied by 100. The overall

IOA for all independent variables was 92.8%. Agreement for treatment efficacy was calculated by dividing the smaller percentage by the larger percentage and multiplying it by 100. The overall IOA for treatment efficacy was 83.1%. IOA for the efficacy measure resulted in some data sets being rescored due to ambiguity and disagreement across raters. Retraining was conducted to help improve IOA scores.

Results

Literature Search

Initially, the preliminary search resulted in a total of 4,057 articles. The PubMed search yielded 7,341 articles. Based on initial review of the titles or abstracts, 321 articles were kept for further review. After further review, 227 articles were excluded based on the aforementioned criteria or duplicates (PubMed), resulting in 94 total articles. The most common reason for exclusion was aggregated dependent variables. That is, although a study may have reported treating SIB, closer examination of the study revealed that data were reported as "problem behavior," which included several behaviors in the same response class. Other reasons for exclusion were that SIB was not targeted, only an assessment was conducted, or a nonbehavioral treatment (e.g., pharmacological) was used. A second rater conducted preliminary searches using the same key terms for 12% of the journals. The number of articles that were ultimately kept and included in the review were compared using exact agreement. IOA for the articles included in the review was 100%.

Ultimately, 94 articles from 20 journals spanning the years 2001-2016 were identified. These articles included 133 data sets (e.g., participants) (Table 1). *The Journal of Applied Behavior Analysis (JABA)* had the largest number of articles and data sets, which accounted for over a third of all articles (37.1%) and almost half of all data sets (46.3%) (see Table 1). The

cumulative number of SIB articles and data sets from 2001-2016 were combined with the original Kahng et al. (2002a) data depicting an overall decline in SIB studies since 1964-2000 (Figure 1). Specifically, the mean rate of SIB treatment articles between 2001-2016 was 6.1 articles per year, a considerable decrease from 1991-2000, which found 16.5 articles per year (Kahng et al, 2002a). However, the mean number of participants in the current review was 1.4 compared to a mean of 1.8 participants in the Kahng et al. review. The mean number of articles was calculated by dividing the total number of articles (i.e., 94) by the total number of years (i.e., 16). The mean number of participants was calculated by dividing the number of participants (i.e., 133) by the total number of articles. These means allowed us to evaluate the rate of SIB treatments over time.

Demographic Characteristics

Participants. Table 2 depicts a summary of the participants' characteristics. The majority of participants were male (61.7%) and diagnosed with severe or profound IDD (47.4%) compared to 3.8% of those who were diagnosed with moderate IDD and 1.5% of individuals diagnosed with mild IDD. ASD was the most common secondary diagnosis (40.0%). Kahng et al. (2002a) reported that their participants were most commonly male and diagnosed with severe/profound IDD and a visual impairment.

The most common age groups were children 0-10 (30.8%) and individuals 19 and over (30.1%). These results are similar to Kahng et al.'s (2002ab) reviews, as their most common age groups were also 19 years and older and then children 0-10 years old.

Treatment Setting. The most common SIB treatment settings were schools (24.1%) or hospitals (15.6%). Less common treatment settings were 'other settings' (12.8%), home (12.8%),

and the clinic (9.2%). Kahng et al. (2002a) reported the most common settings were residential institutions, followed by hospitals or schools.

Topography

Table 3 depicts the most common topographies of SIB. Overall, 26.3% of participants engaged in multiple forms of SIB. Similarly, Kahng et al. (2002a) also found that 27.6% of participants engaged in multiple SIB topographies. The most common topographies included head banging/head hitting (25.1%), biting (13.8%), other forms of SIB (12.3%) hand mouthing (10.8%), and body hitting (8.9%) (Table 3). "Other" topographies widely varied from aerophagia, corprophagia, to pulling off one's nails. The remaining topographies did not occur in more than 10% of cases. However, compared to the Kahng et al. review, the top five most common topographies are the same, with the exception of "other self-injury".

Severity / Intensity Reported. The history, severity, or intensity of SIB were reported for 62.4% of participants. Those studies that did so, indicated that 33.1% of cases were severe SIB, while 62.4% did not mention the severity level. SIB resulting in tissue damage was noted for 31.6% of participants, no reported tissue damage for 9.8% of participants, and 58.6% of cases did not mention whether SIB was severe enough to cause tissue damage. The SIT scale was not used in any of the studies.

Methodology

Interobserver Agreement. IOA was reported for 95.5% of all participants, an increase from 76.8% in the Kahng et al. (2002a) review.

Experimental Design. The majority of participants' treatments were evaluated using a single-case experimental design with replication (88%), an increase from the Kahng et al.

(2002a) review (65.3%). Most commonly, those studies that did not use an experimental design used an AB design or had no baseline.

Treatment Application

Functional Assessment. A functional assessment was conducted for 91.7% of participants. The most common was the experimental functional analysis (78.2%) and the least common was a descriptive analysis (12.8%). No functional assessment was conducted for 8.3% of participants. Conversely, Kahng et al. (2002b) reported that 62.2% of participants were not reported to have a functional assessment. Similarly, their review indicated that the most common functional assessment was an experimental functional analysis and the least common was an indirect assessment. Figure 2 displays the cumulative number of functional assessments as they relate to the use of reinforcement and punishment-based procedures from the Kahng et al. and the current review. Both studies demonstrate an overall increase in functional assessments, with a reliance on reinforcement-based interventions.

Reported SIB Functions. The most common function of SIB was automatic reinforcement (52.6% of participants) as compared to 27.5% of participants in the Kahng et al. (2002b) review (Table 4). Social positive (14.3%) and multiple functions (13.5%) were the next most common SIB functions. Kahng et al. reported that social negative reinforcement, automatic reinforcement, and social positive reinforcement, were the three most common functions of SIB.

FERB. A FERB was taught for 30.1% of participants, with 32.3% of participants not being taught a FERB. For 37.6% of participants, there was a replacement behavior taught, however, the behavior was not functionally equivalent. The most common example was that there was no clear identifying reinforcer for automatically maintained SIB, yet some type of FERB was taught.

Treatment Applications

Table 5 depicts the total number of treatment applications. In total, there were 631 treatment applications compared to 1,035 applications in the Kahng et al. (2002a) review. The most common were reinforcement-based procedures (39.9%). Among them, noncontingent reinforcement (NCR) was the most frequently used (21.9%), followed by differential reinforcement of alternative behavior (DRA) (14.3%) and differential reinforcement of other behavior (DRO) (3.8%). Punishment procedures were less widely used, occurring in 9.0% of interventions. The most common punishment application was "punishment – other" (2.4%) which did not include any of the listed procedures. For example, these included procedures such as reprimands and redirection. Secondly, demands were the next most common punishment procedure used in 1.3% of applications.

The current review also incorporated a treatment package component when there were multiple treatments presented together. Treatment packages were included for 19.5% of participants. Other treatment categories besides reinforcement or punishment included: antecedent manipulations (15.1%) response blocking (6.8%) extinction (5.1%) mechanical restraint (2.5%), and "other" treatments not listed (1.7%).

Efficacy. The mean treatment efficacy was a 66.8% reduction in SIB from baseline to treatment across 2001-2016 (Figure 3). This was a decrease from the overall efficacy in the Kahng et al. (2002a) review that found an 83.7% mean reduction in SIB. Punishment-based, extinction, and mechanical restraint procedures successfully reduced SIB when used alone, and with a functional assessment by at least 80% (Table 6). These results suggest that the current interventions are less efficacious than those reported in the Kahng et al. (2002ab) reviews. Table 6 depicts the percentage of treatment efficacy alone and in conjunction with other treatments,

following the use or non-use of a functional assessment. For example, antecedent interventions alone were found to be 54% efficacious without a functional assessment, and only 24.7% efficacious when a functional assessment was completed. When antecedent interventions were conducted with punishment and no functional assessment, they were 100% efficacious. Results vary as there is no clear trend among the treatment efficacy and whether or not a functional assessment was used.

Complete Suppression. Complete suppression was indicated if the final three data points were 0 or 0% SIB. A total of 28.3% of treatments resulted in complete suppression. The treatments that completely suppressed SIB were punishment-based procedures (47.1%), treatment packages (38.3%), extinction (33%), and reinforcement procedures (16.8%). Response blocking (14.3%), antecedent manipulations (11.5%), and 'other' treatment (0%) were less likely to completely suppress SIB.

Maintenance and Generalization

Generalization probes were conducted for 22.2% of participants. The most common generalization was programmed across settings (15.6%) and people (5.9%). Maintenance was conducted for 22.6% of participants and ranged from the same day, to up to five years later.

Social Validity and Treatment Integrity

Social validity data were reported for 4.5% of participants, while treatment integrity data were reported for 12.8% of participants.

Discussion

The current study was a replication and extension of the SIB treatment literature reviews by Kahng et al. (2002ab). Specifically, this study viewed SIB as a behavior based solely on learning histories, while examining various correlates to its occurrence. This review continues to

focus on small-*N* treatment investigations, and also contributes to the external validity of the treatment results. It should be noted that the current results are specific to SIB. Many studies were excluded in which SIB was part of a more general response class, such as 'problem behavior' or 'destructive behavior', etc. Consequently, the discussion and the interpretation of the results may not be applicable to all individuals with IDD and severe problem behaviors, with or without SIB, as part of that response class. This review also provides an important update on trends in behavioral assessment and treatment outcomes that warrant further consideration.

The current results suggest some noteworthy trends and shifts within the SIB treatment literature as compared to the original Kahng et al. (2002ab) reviews. Most notably, there was a decline in the number of published SIB treatment studies, a shift in diagnoses of individuals who engage in SIB from IDD to ASD, a change from a majority of individuals engaging in socially mediated SIB to automatically maintained SIB, and an overall decrease in treatment efficacy. Some similarities did emerge such as the same most common SIB topographies and a continued reliance on functional assessments to produce reinforcement-based interventions. Lastly, the current review revealed a lack of treatments that produced complete SIB suppression and taught FERB, as well as poor maintenance, generalization, treatment integrity, and social validity data. These data are concerning given the years of behavioral treatment research on SIB and the presumption that treatment efficacy would have improved over time.

As mentioned, there was a large decline in the number of published SIB treatment studies since the Kahng et al. (2002ab) reviews. The most common journal with studies treating SIB was the *JABA.* This may be expected given that *JABA* is considered one of the "flagship" journals within the field of applied behavior analysis and single-case experimental designs (Elliott, Morgan, Fuqua, Ehrhardt, & Poling, 2005). However, despite the identical searches in the same

journals, in addition to seven additional journals, the overall number of experimental articles that treat SIB has reduced over time. One potential reason for this decrease could be that more studies are focusing on treating response classes as opposed to targeting SIB as an isolated behavior. Those studies that targeted "problem behavior" and aggregated a variety of problem behavior topographies, were excluded from this review as the specific SIB treatment efficacy could not be determined. For example, Rapp, Vollmer, and Hovanetz (2005) treated swimming pool avoidance in an adolescent girl diagnosed with ASD. Her avoidance behaviors were defined as elopement, flopping, face hitting, self-choking, and screaming. A blocking and shaping procedure were introduced with measured effects on "problem behavior." The overall rate of problem behaviors was measured, with no distinction of treatment effects on face hitting or self-choking, specifically. As such, studies such as this were excluded from the current review.

Although this may be a plausible explanation for the decline in SIB treatment studies, previous data on the number of excluded studies due to aggregated problem behavior were not reported, so direct comparisons cannot be made. Further investigation into this possibility may be warranted. Another theory could be that since behavioral treatments have demonstrated overall efficacy, researchers have shifted focus to study more variables that correlate with or better explain SIB causes (e.g., Hagopian et al., 2015; Hagopian et al., 2017). These studies would support the Kahng et al. (2002ab) proposal for a need for SIB prevention, instead of intervention. Similarly, as discussed below, the published literature reports an increase in automatically maintained SIB. Perhaps socially mediated SIB has become less difficult to treat based on the wealth of available published literature on behavior interventions (e.g., Fisher, Piazza, & Roane, 2011). As such, investigators may be shifting their attention to specifically research more complex cases of automatic SIB.

Another trend included the shifts in diagnoses among those who engaged in SIB. Most notably, there was a major increase in individuals diagnosed with ASD, as compared to the Kahng et al. (2002a) review. There was also a noteworthy decline in individuals diagnosed with severe or profound IDD. These data may not be entirely unexpected given the increasing trend in ASD diagnoses that has occurred over the last decade (American Psychiatric Association, 2013). Moreover, with the greater prevalence and awareness of ASD, in general, what was previously diagnosed as severe or profound IDD, may now be more commonly diagnosed as ASD due to symptom substitution (reclassifying of children from one diagnostic criteria to another) (Croen, Grether, Hoogstrate, & Selvin, 2002; Shattuck, 2006). The overall impact in diagnoses shifts may not directly impact SIB treatment outcomes. However, it may help elucidate some common characteristics of ASD (e.g., lack of communication, repetitive/stereotypical behaviors) that may contribute to SIB prevalence.

Nevertheless, despite the decline in the number of SIB treatment studies specifically, there are some similarities between the current results and from Kahng et al. (2002ab). For example, the most common SIB topographies have not shifted. Specifically, the top six most common topographies in the current review matched the top five most common topographies in the Kahng et al. (2002a) review. The one distinction was that “other self-injury” was the second most common topography in the current review, including all other topographies not already listed. For example, those topographies that did not fit into the previously listed categories such as hyperventilation, ear digging, or joint dislocation.

Functional Assessment and Functions of SIB

Similarly to the Kahng et al. (2002ab) reviews, the cumulative number of studies that conducted an FBA appeared to correspond with the cumulative number of reinforcement-based

procedures. These data are also consistent with previous research that demonstrated a decline in punishment-based procedures (Lydon, Healy, Moran, & Foody, 2015). These findings are likely expected given the emphasis on less-restrictive treatments, especially when the function of behavior can be identified. However, it is important to consider the possibility of a publication bias that is inherent within the published treatment literature (Sham & Smith, 2014). Most likely, SIB treatment studies will not be considered as best practice and published, unless there is evidence that some kind of FBA was conducted. Thus, the SIB studies that did not conduct an FBA will be less likely to be published. Therefore the data reflecting the utility of FBA may be overrepresented, especially as it occurs in research.

One of the most substantial findings was the shift in the most common functions that reportedly maintained SIB. Kahng et al. (2002b) reported consistent findings with Iwata, Pace, et al. (1994) that SIB was most commonly maintained by social negative reinforcement. Conversely, the current results revealed that SIB treatment studies focused more on SIB maintained by automatic reinforcement. These data are consistent with the behavior treatment review by Gregori et al. (2017) in which adults diagnosed with IDD were found to most frequently have SIB maintained by automatically reinforcement. Thus, taken together, these data suggest that perhaps there has been a shift in research priority to treat more complex SIB maintained by automatic reinforcement (e.g., Hagopian et al., 2015, Hagopian et al., 2017).

The conceptualization of automatically reinforced SIB with individuals with IDD has proposed a relationship with pain attenuation or alleviation of discomfort (i.e., automatic negative reinforcement). Previous research has discussed how chronic SIB may typically present as repeated attempts to stimulate localized, body sites as opposed to targeting random areas of the body (Symons & Thompson, 1997). As such, it could be inferred that an individual engages

in this repetitive response as a way to reduce the discomfort or pain associated with that area. By doing so, one learns over time that engaging in SIB will minimize or remove the painful stimulation. In other words, painful stimulation acts as an establishing operation, increasing the value of pain removal, and all behaviors that previously resulted in pain reduction (Michael, 1993). If one has learned from an early age that hitting or slapping the affected area removes such pain, this behavior will likely continue in the future. Although an operant analysis of SIB is clear, other reports have asserted that the, "link between SIB and pain is highly variable and difficult to predict" (Schroeder et al., 2001). This relationship is made even more complex as it pertains to individuals with impaired communication, such as individuals with IDD (Schroeder et al., 2001). Further research examining the relationship between SIB and painful stimulation is needed to better understand why severe forms of SIB may occur, and how best to prevent it.

It is important to note that consistent with previous research (e.g., LeBlanc, Patel, & Carr, 2000; Vollmer, 1994), two patterns of responding during the FA were indicative of an automatic reinforcement function. These included responding solely in the alone condition and no to low responding in the control condition and responding across all FA conditions in relation to the control condition (Hagopian et al., 1997). In either case, responding is considered automatically maintained. Thus, it may be that in some cases, SIB was not strictly automatically maintained, but could have been multiply controlled or undifferentiated. In most cases, the author(s) considered these cases to be automatically maintained SIB and were reported as such. Therefore, current results indicating a higher prevalence of automatic functions could arguably be inflated.

Treatment Efficacy

One of the most important dimensions of applied behavior analysis is efficacy (Baer, Wolf, & Risley, 1968). Baer et al. defined efficacy as producing large enough changes for

practical value. In this review, the overall treatment efficacy reduced by nearly 20% from the Kahng et al. (2002ab) reviews. However, the overall efficacy for both punishment-based and extinction procedures were similar to the original findings. These data would suggest that punishment and extinction procedures have continued to maintain their effects over time. Conversely, reinforcement-based, antecedent manipulations, response blocking, and mechanical restraint procedures were found to decrease in efficacy, as compared to the original reviews. A decrease in reinforcement efficacy may be correlated with the increase in SIB cases that are maintained by automatic reinforcement (Rooker et al., 2018), and the subsequent resistance to treatment as a result (Hagopian et al., 2015, Hagopian et al., 2017). Additionally, given the low percentage of studies that taught a FERB, appropriate replacement behaviors may have only contacted minimal reinforcement (for further discussion on treatment resistance with automatically reinforced SIB, see Rooker et al., 2018).

Although the findings on punishment and extinction efficacy are consistent with previous reviews (Kahng et al., 2002a, Rooker et al., 2018), concerns about the use of these procedures warrants discussion. Ethical guidelines and compliance codes (e.g., Board Certified Behavior Analyst) consider punishment procedures to be a last resort. If conducted, these procedures should only be done in conjunction with reinforcement procedures for appropriate behaviors. For example, Rooker et al. reported in their review that other less intrusive procedures were at minimal, equally effective, or suppressed automatically reinforced SIB. On rare occasions, if the severity of the SIB is deemed such that immediate reduction is vital, then punishment procedures may be considered. Other important considerations such as medical professionals may also be needed. However, in this review, only a third of cases reported the SIB as severe or resulting in tissue damage. In only 4% of cases was the SIB considered as life threatening. Therefore, future

studies should follow general ethical and compliance procedures when dealing with SIB treatment.

SIB has been theorized as occurring due to biological sources of reinforcement, which are less responsive to treatments based on environmental contingencies (Kahng et al., 2002a). Another theory is that some SIB has been found to change functions over time, thereby, making it more difficult to treat it appropriately (Lerman, Iwata, Smith, Zarcone, & Vollmer, 1994).With the increased reports of automatically maintained SIB over the last 15 years, conceivably, this increase contributes to the overall reduced treatment efficacy, in general, and across four of the treatment categories listed above. For example, Iwata, Pace, et al. (1994) reported differences in the treatment efficacy of differential reinforcement and noncontingent reinforcement for socially reinforced and automatically reinforced behaviors. Both reinforcement procedures were successful in more than 90% of applications for socially mediated SIB, whereas, these treatments were efficacious in approximately 65% of applications for automatically maintained SIB. Previous research has supported the difficulty with treating behaviors that are maintained by automatic reinforcement (e.g., Miltenberger, 2005; Vollmer, 1994). Treatment of automatically maintained SIB would require identifying the putative reinforcers that compete with the reinforcing value of SIB (Vollmer, 1994). Additionally, the reinforcers for automatically maintained behavior are continuously available to the individual (Hagopian et al., 2015; Hagopian et al., 2017). Much of these difficulties are likely due to the lack of precise identification of the maintaining variable that could control the behavior (Rooker et al., 2018).

A proposed solution can be a focus on antecedent strategies as a preventative measure for SIB (Kahng et al. 2002a). For example, Hagopian et al. (2015) and Hagopian et al. (2017) have started to investigate the differences among different subtypes of automatically maintained SIB.

Specifically, how these subtypes may better affect treatment decisions. These authors have hypothesized that SIB that occurs primarily during the alone condition may respond to treatment differently than SIB that occurs across all FA conditions. As such, the most effective treatments would vary. Further investigation and evaluation on how automatically maintained SIB is sensitive to different contingencies is warranted.

Another solution may be to increase the use of treatment integrity procedures. Previous research has suggested that improved treatment procedures may result in decreases in problem behavior (DiGenarro, Martens, & Kleinmann, 2007). The current findings reported a dismal number of studies that included treatment integrity measures. Consequently, a majority of SIB treatments were implemented without any verification they were conducted correctly. The ramifications for poor integrity could potentially be a contributing factor to explain the overall decrease in treatment efficacy. As such, it is imperative for those working with individuals with IDD to include treatment integrity measures. Unfortunately, this trend is not specific to only SIB treatments. The field of applied behavior analysis, in general, needs to increase the use of measurements to improve treatment accuracy (McIntyre, Gresham, DiGennaro, & Reed, 2007).

The current review measured the complete SIB suppression for each type of treatment. Despite some efficacious treatment results, no treatment category was found to completely eliminate SIB on 80% or more opportunities. Overall, punishment-based procedures were found to be most efficacious, while reinforcement-based procedures were one of the least likely procedures to completely eliminate SIB. The social significance of these findings may vary based on the severity of the SIB. However, according to Baer et al. (1968), efficacy means there needs to be a large enough practical behavior change. The current data indicated that when the SIB severity was reported as “life threatening”, only 42% of the time was SIB completely

suppressed. These data imply that 58% of the time, SIB was not reported as completely suppressed and therefore could have led to life threatening injuries. For severe SIB, the behavior was completely suppressed close to 50% of cases, and when it resulted in tissue damage, only 37% of cases. As such, these data draw concerning conclusions about the efficacy of SIB treatments as it relates to the severity of the behavior. For individuals who engage in more severe SIB, failure to completely suppress this behavior could still result in significant injury or harm, which may be considered unacceptable. Overall "acceptable" reductions in rates of SIB will vary dependent on the severity, frequency, and intensity of the behavior. Moreover, not completely suppressing low intensity and severe SIB may be more acceptable if there is still a demonstrated level of change from baseline levels. This discussion further supports the importance of social validity measures when treating SIB.

A large number of data sets did not include the degree or severity of SIB. Severity or intensity of behavior can be a difficult dimension to measure, which may explain why so few studies reported on it. However, a more objective measure such as the SIT was not used across any of the reviewed studies. Similarly, few studies reported on whether tissue damage occurred as a result of SIB. It is important to caution that just because the level of injury or severity was not reported, does not mean that injury did not actually occur. In a majority of cases it was just unknown/not reported. Future treatment studies should discuss the degree to which injury or other harm occurs as a result of SIB, especially as it relates to the treatment efficacy.

Due to the difficulty and the lack of measuring injury severity, this calls into question whether the "injurious" in SIB is actually truly harmful behavior. In some cases, it may be more accurately described as repetitive behavior or stereotypy. Richman and Lindauer (2005) referred to these common types of SIB that do not produce tissue damage as proto-SIB. Some common

examples of proto-SIB could include things such as hand mouthing, poking eyes, and clapping hands. When displayed repetitively and with mild force, these behaviors may be better described as stereotypy. However, if completed with more force, these behaviors could be described as self-injurious, as it results in harm to one's body. Consequently, it is argued that future studies should more specifically describe the SIB severity so as to more confidently make the distinction between self-injury and stereotypical behaviors. This distinction should also help to inform the frequency or intensity of treatment.

FERB

Another finding was the lack of FERB that were programmed. Replacement behaviors were included for 67% of participants. However, for 37% of participants, a non-functionally equivalent replacement behavior was taught. This lack of a taught FERB may be correlated with an increase in automatically maintained SIB. Due to the difficulty with identifying the precise reinforcement for many topographies of automatically maintained SIB, it is then difficult to replace the maintaining reinforcer. In some studies, the authors referred to a FERB, however, upon review, the behavior taught was unknown whether it was functionally equivalent. As mentioned, in most cases, this was due to the lack of identifying the reinforcing aspect of the SIB. Future research should more precisely evaluate the use of FERB and strive to identify the exact maintaining variables to affect best treatment outcomes.

Generalization / Maintenance / Social Validity

For optimal outcomes, treatment effects should maintain over time and ideally across other people, settings, or materials (Stokes & Baer, 1977). If SIB reduces in the treatment setting but does not maintain in other places or over time, many would argue that the treatment efficacy is not socially significant. Pragnell (2009) cautioned against drawing conclusions based on

treatment effects due to a reported lack of long-term maintenance or follow up on SIB. Likewise, social validity measures should be used so that caregivers or participants can evaluate the treatment efficacy and provide feedback. Overall, across all studies, there were a lack of social validity, generalization, and maintenance. These data are concerning given the field's reliance on the seven dimensions of applied behavior analysis (Baer et al., 1968) and the call for inclusion of social validity (Wolf, 1978).

Limitations

Although the review suggested that behavioral interventions are efficacious, the effectiveness of treatments in "real world" settings are unknown (Gartlehner, Hansen, Nissman, Lohr, & Carey, 2006). In many cases, there was a lack of detail pertaining to the environments in which the studies were conducted. Consequently, this draws into question the efficacy versus effectiveness of certain treatments. Future reviews should more closely examine the effectiveness of behavioral interventions for SIB treatment.

Another limitation was the nature of the data extraction procedure. The same data can be extracted multiple times, each time revealing somewhat minor but arguably negligible variations. It may most closely approximate what the raw data depict, however, may not be exact to the original data. Further support for the difficulty with reliability is provided by the lower IOA scores for efficacy, and the subsequent need for retraining. Ideally, reviews should incorporate the original data so that there are no discrepancies when calculating treatment efficacy. However, this is not always a possibility. Finally, the inherent nature of a replication study required the categorization of variables identical to those used in Kahng et al. (2002ab)'s review, to allow for direct comparison. As such, there was some difficulty with categorizing the current data into the

preexisting categories due to differences or changes in definition (e.g., variations of the treatments fitting into the preexisting categories)**.**

Future Research

Considering the overall reduction in published SIB treatment studies, it is currently unclear as to the possible variables contributing to this decrease. Future studies could more systematically examine this outcome, evaluating the number of treatment studies targeting SIB exclusively, as well as in response classes. Additional variables that may be affecting the decline in SIB treatment should also be investigated so as to help explain this shift over time.

Secondly, this review was one of the first to identify automatic reinforcement as the most commonly reported maintaining variable of SIB in the published, peer-reviewed literature using single-case designs to evaluate behavioral treatments. The concept of automatic reinforcement continues to be a complex topic when considering treatment options. Often the specific reinforcing aspect of the SIB is not easily identifiable and therefore may be often assumed, making treatment difficult. As such, studying other correlates or variables when SIB is automatically maintained may be a better predictor of successful treatment outcomes (e.g., Hagopian et al., 2015; Hagopian et al., 2017). In two studies, Hagopian and colleagues have provided some initial recommendations of the delineating of subtypes for automatically maintained SIB. By doing so, this allows clinicians to better understand how reinforcing contingencies affect different SIB types sensitivity to treatment. This subtyping may lead to better treatment predictability and optimal treatment outcomes. As such, more research on improving the efficacy of SIB treatments is warranted.

Further, the current data report that about a third of the time a FERB that matches the reinforcer is taught. Slightly more than a third of the time, a replacement behavior is taught, but

it does not match the specific reinforcing consequences of the SIB. The current data suggest that when SIB is automatically maintained, the likelihood of a FERB being taught is reduced. Given the complexity with automatically maintained behaviors, it is understandable that the FERB may not match and therefore not completely eliminate or suppress the SIB. Further research in the area of identifying FERB for these types of behaviors is needed to evaluate whether teaching replacement behaviors alone can increase overall treatment efficacy. Likewise, more practical assessments or evaluations to identify maintaining variables should be identified for automatically reinforced SIB.

Finally, another area ripe for consideration is the evaluation of SIB treatment efficacy. Further examination of the variables affecting treatment efficacy and how this can help inform and improve outcomes is needed. Reinforcement-based procedures are so often relied on and considered best practice, however, the current review found that within the published, peer-reviewed literature, reinforcement procedures alone were not reported as the most efficacious. Additional treatments may be necessary to supplement reinforcement-based procedures. Moreover, as previously mentioned, the increase in automatically maintained SIB has likely increased the difficulty with identifying the appropriate reinforcers that can compete with the reinforcing value of the behavior itself. Further evaluation into how to strengthen reinforcement-based procedures, as well as understanding treatment interactions are warranted. Interventions that completely suppress SIB require further investigation as the current data reflect poor treatment outcomes. Some may argue that supplemental treatments such as the use of medications could compliment the use of behavioral treatments, particularly when the precise reinforcing variables are difficult to identify. Taken together, pharmacological treatments could be prescribed in some cases, but then faded over time as behavioral treatment become more

efficacious. Finally, and perhaps most importantly, Kahng et al. (2002a) proposed that more focus on prevention may be necessary when treatment alone is insufficient. The current review supports this conclusion and encourages this suggestion as best practice to improve the overall outcomes of individuals who display SIB.

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Table 1. Distribution of Journals Publishing Articles on the Treatment of SIB.

Journal	No. of articles	No. of data sets
Journal of Applied Behavior Analysis	35	62
Behavioral Interventions	13	15
Journal of Developmental and Physical Disabilities	9	10
Behavior Modification	5	7
Other (less than 5 articles)	32	39
Total (N = 21 journals)	94	133

Participant Characteristic	No. of data sets	%
Gender		
Male	82	61.7
Female	51	38.3
Level of IDD		
Severe/Profound	63	47.4
Moderate	5	3.8
Mild	2	1.5
No data / none	63	47.4
Age		
0-10	41	30.8
11-18	37	27.8
19 and over	40	30.1
No data	15	11.3

Secondary[a]		
Autism	62	40.0
Cerebral palsy	10	6.5
Visual impairment	8	5.2
Hearing impairment	6	3.9
Down syndrome	2	1.3
Rett syndrome	2	1.3
Lesch-Nyhan syndrome	0	0
Other	62	40.0
None / no data	3	1.9

Topography[a]	No. of data sets	%
Head banging/hitting	51	25.1
Biting	28	13.8
Other SIB	25	12.3
Hand-mouthing	22	10.8
Body-hitting	18	8.9
Pica	17	8.4
Scratching	9	4.4
Vomiting/rumination	7	3.4
Skin-picking	6	3.0
Hair-pulling	6	3.0
Eye-poking	5	2.5
Other (less than 5 data sets)	8	4.0
No data	1	0.5

[a] Some data sets include more than one topography

Function	No. of Data sets	% in current review	% in Kahng et al. 2000b	% in Iwata, Pace, et al. 1994
Social negative reinforcement	19	14.3%	31.3%	38.1%
Social positive reinforcement	14	10.5%	26.4%	26.3%
Automatic reinforcement	70	52.6%	27.5%	25.7%
Multiple functions	18	13.5%	6.8%	5.3%
Unknown	12	9.0%	7.9%	4.6%

Treatment	No. of applications [a]	% [b]
Reinforcement [c]	252	39.9
NCR	138	21.9 (54.8)
DRA	90	14.3 (35.7)
DRO	24	3.8 (9.5)
Punishment	57	9.1
Other (punishment)	15	2.4 (26.3)
Demands	8	1.3 (14.0)
Manual restraint	6	1.0 (10.5)
Shock	6	1.0 (10.5)
Protective equipment	6	1.0 (10.5)
Response cost	6	1.0 (10.5)
Other	11	1.7
Treatment package	123	19.5
Antecedent manipulation	95	15.1
Response block	43	6.9
Extinction	32	5.1
Mechanical restraint	16	2.5
Exercise (antecedent to)	2	0.3

[a] Data sets may have included several different treatments.

[b] Numbers in parentheses represent the percentage of applications within that particular treatment category (i.e., reinforcement or punishment)

[c] DRO = differential reinforcement of other behavior, DRA = differential reinforcement of alternative behavior, NCR = noncontingent reinforcement

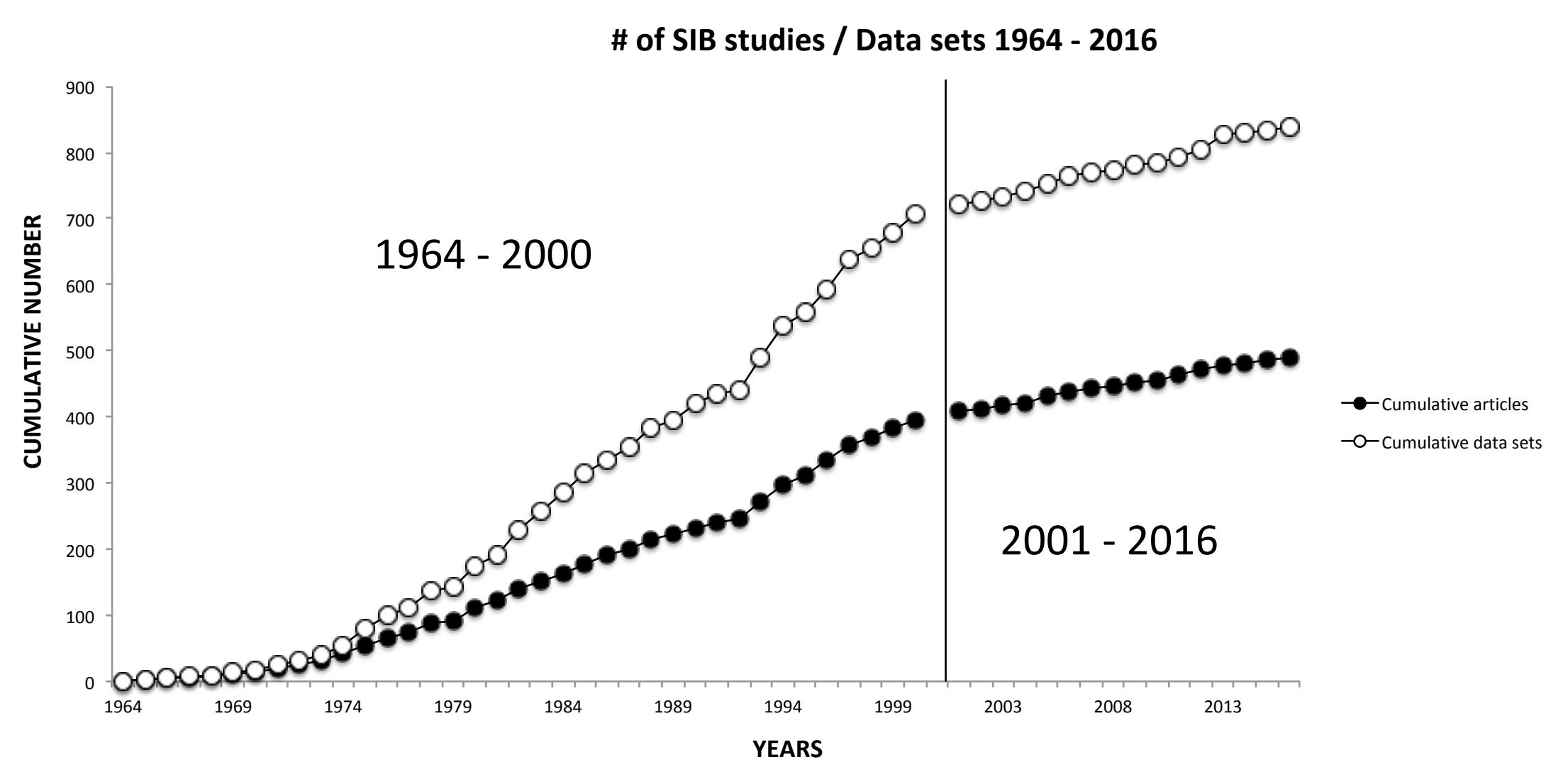
	Antecedent		Extinction		Reinforcement		Punishment		Response block		Mechanical restraint	
Functional Assessment	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Antecedent	54.0.% (n =12)	24.7% (n=14)				85.6% (n=28)						
Extinction	0% (n=2)			82.7% (n=3)								
Reinforcement			86.3% (n=2)	77.4% (n=13)	91.3% (n=1)	65.0% (n=105)				61.1% (n=23)		
Punishment	100% (n=2)				45.3% (n=2)	61.1% (n=12)	98.2% (n=5)	85.7% (n=29)				

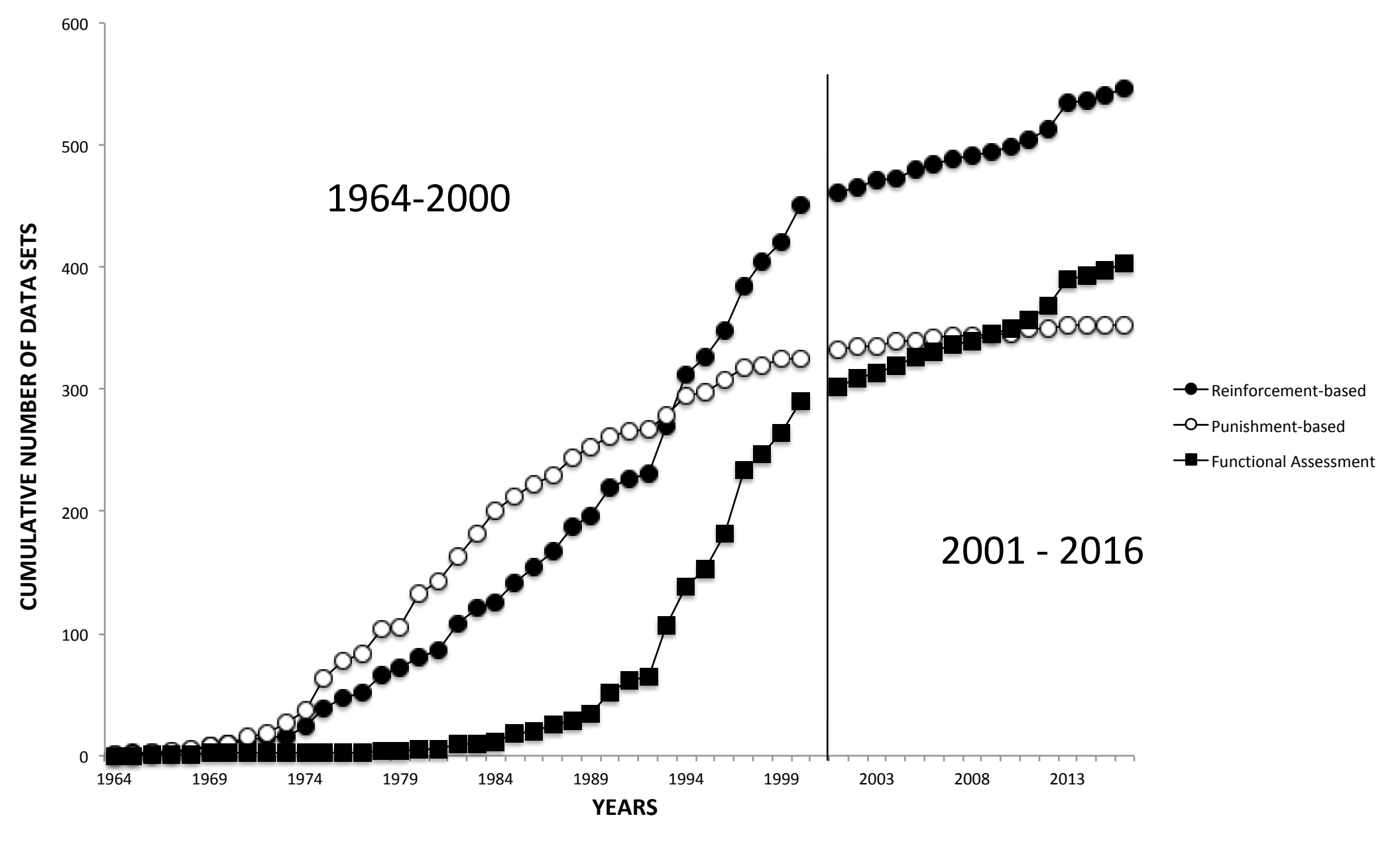
Response block			57.9% (n=1)	60.7% (n=6)	52.3% (n=7)	
Mechanical restraint	68.2% (n=1)	58.2% (n=3)				84.9% (n=8)

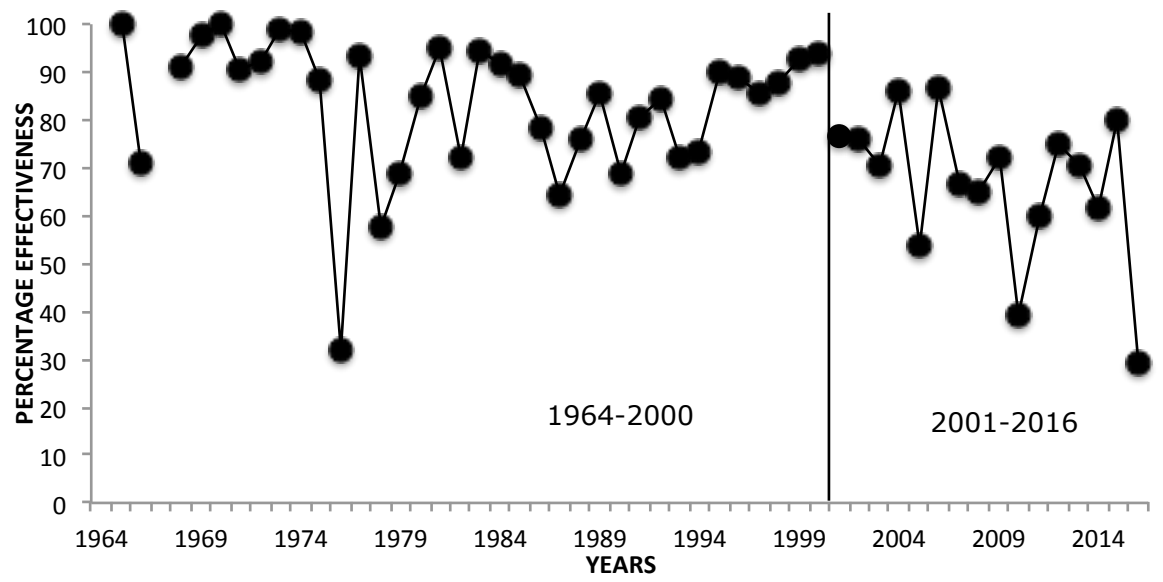
[a] Mean percentage of reduction in SIB

[b] Identical column and row labels

[c] Different column and row labels


# of SIB studies / Data sets 1964 - 2016
CUMULATIVE NUMBER
900
800
700
600
500
400
300
200
100
0
1964 - 2000
2001 - 2016
1964
1969
1974
1979
1984
1989
1994
1999
2003
2008
2013
YEARS
Cumulative articles
Cumulative data sets


600
500
400
300
200
100
0
CUMULATIVE NUMBER OF DATA SETS
1964-2000
2001 - 2016
1964
1969
1974
1979
1984
1989
1994
1999
2003
2008
2013
YEARS
Reinforcement-based
Punishment-based
Functional Assessment


PERCENTAGE EFFECTIVENESS
100
90
80
70
60
50
40
30
20
10
0
1964
1969
1974
1979
1984
1989
1994
1999
2004
2009
2014
YEARS
1964-2000
2001-2016