Self-Injury

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Introduction

One of the most perplexing and challenging forms of behavior in autism spectrum disorder (ASD) is self-injury. Self-injurious behavior (SIB) has been reported in clinical documentation and in the research literature to take various forms including self-hitting, head banging, self-pinching, self-scratching, eye-gouging, self-kicking, hair-pulling, self-biting, and many others. There are also other, more discrete forms of behavior that are self-injurious, such as aerophagia (i.e., swallowing air; Holburn, 1986), chronic hand mouthing (Roscoe et al., 2013), and bruxism (teeth-grinding; Lang et al., 2009).

Of course, not all individuals with ASD display SIB, but the problem is significant in that population. For example, Steenfeldt-Kristensen et al. (2020) conducted a meta-analysis of published studies reporting prevalence of SIB. Of the 14,379 participants across 37 reports, 42% engaged in some form of SIB. The prevalence statistics vary widely in different studies, but all suggest that the problem is far greater in ASD

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than in the general population (Dominick et al., 2007).

Although SIB is commonly described as highly repetitive behavior that can occur at frequencies of up to dozens of instances per minute (Iwata et al., 1994a), the behavior also can be episodic insofar as it either occurs under highly specific stimulus contexts or in bursts after long periods without problematic behavior (e.g., O'Reilly, 1997). A majority of the evidence suggests that SIB is learned behavior that is often inadvertently reinforced by common social consequences to the behavior, such as attention from adults, access to preferred items or activities, or escape from instructional or undesired activities. Sometimes the behavior occurs because it produces stimulation by itself (e.g., Piazza et al., 2000) and, therefore, will persist in the absence of social reinforcement (a phenomenon known as "automatic reinforcement," Skinner, 1953; Vaughan & Michael, 1982).

In this chapter, updated from Vollmer et al. (2009), we will first describe the known "operant functions" of SIB. Second, we will describe behavioral assessment methods for SIB. Third, we will describe how the assessment information can be used to initiate behavioral treatments. Not all of the examples used will come directly from participants with ASD, but the same or similar principles apply.

Origin and Maintenance of SIB

For the past several decades, research on functional analysis and treatment of SIB have shown that such behavior is often maintained via operant reinforcement contingencies, and that the learning history produced by reinforcement can be overridden by new contingencies during treatment (Iwata et al., 1994b; Hagopian et al., 1998). These operant contingencies include social positive reinforcement, social negative reinforcement, and automatic reinforcement. There is also evidence to suggest that a subset of SIB is primarily controlled by antecedent variables.

Some SIB is maintained by socially mediated positive reinforcement. *Socially mediated* means only that the reinforcement is delivered by another person. *Positive* means that some stimulation is *presented* as a consequence to behavior. *Reinforcement* means *to strengthen* (in the sense that behavior is more likely to occur under similar circumstances in the future). Of course, few care providers would intentionally reinforce SIB, but many natural reactions from the social environment inadvertently produce a reinforcement effect. Socially mediated reinforcement can be in the form of reprimands, comfort statements, or physical proximity (Iwata et al., 1994b) or can be tangible items such as food, toys, or activities. It is a very common and perhaps even a natural adult response to reprimand, comfort, or try to calm down an individual when severe behavior occurs (e.g., Thompson & Iwata, 2001), and probably, the adult's behavior is, in turn, reinforced by the temporary cessation of SIB (Miller et al., 2010; Sloman et al., 2005). Additionally, it is often impossible to ignore behavior that is severe; safety considerations might require the deliberate reinforcement of SIB.

Some SIB is maintained by socially mediated negative reinforcement, also known as escape and avoidance. Again, *socially mediated* means that it is delivered by another person. *Negative* means that some stimulation is *removed, terminated, or avoided* as a consequence to behavior. *Reinforcement* again means *to strengthen* (increase the future likelihood of) the behavior. Thus, the distinction between socially mediated positive reinforcement and socially mediated negative reinforcement is that in the latter, aversive stimulation is essentially "turned off" when SIB occurs. For example, a care provider might make a request to complete an academic or self-care activity but then stop making requests when SIB occurs (e.g., "okay, we'll do that later"). As with positive reinforcement, such a reaction by a teacher, parent, or other care provider is not intended to reinforce the behavior. Rather, the care provider's termination of instructions or demands is probably reinforced by the temporary cessation of SIB. The problem is that the SIB becomes more likely to occur in similar situations in the future. Socially mediated negative reinforcement is not limited to escape from

instructions or demands; removal of any aversive stimulus, such as a loud peer or nonpreferred food, can also reinforce SIB.

Some SIB is not socially reinforced. In these cases, the stimulus products of the behavior can produce either automatic positive or automatic negative reinforcement (Vollmer, 1994). The term *automatic* means the reinforcement is not delivered by another person (Vaughan & Michael, 1982). Thus, behavior maintained by automatic reinforcement is hypothesized to generate its own consequences. Automatic positive reinforcement can occur if the behavior produces some sort of pleasing sensation. Automatic negative reinforcement can occur when the behavior terminates some aversive physical sensation, such as when self-scratching terminates an itching sensation or ear-hitting momentarily alleviates the pain produced by an ear infection (Cataldo & Harris, 1982).

Pain states and states of discomfort are known to interact with reinforcement contingencies, making dangerous behavior (including SIB) more likely. For example, research has shown that severe problem behavior can increase when the individual is experiencing fatigue (Smith et al., 2016), allergy symptoms (Kennedy & Meyer, 1996), menses (Carr et al., 2003), constipation (Christensen et al., 2008), skin irritation (Peine et al., 1995), ear infections (O'Reilly, 1997), and a host of other conditions. Thus, a thorough understanding of the causes of SIB must not only take into account reinforcement but also physiological states that may exacerbate the deleterious effects of reinforcement. For example, Kennedy and Meyer (1996) showed that negatively reinforced SIB was exacerbated when the participants in their study were experiencing allergies. Similarly, O'Reilly (1997) showed that escape behavior was elevated when their participant experienced ear infections.

Although most SIB appears to be sensitive to social positive, social negative, and automatic reinforcement, there is evidence that some forms of SIB may occur under conditions of aversive stimulation or reinforcer loss even if the SIB is not reinforced (Lloveras et al., 2022). In a specific example, Hutchinson (1977) reviewed literature related to biting (self or others) that showed clearly that organisms, including humans, bite on something when presented with loud noise or other aversive stimulation. Similarly, organisms bite (self, others, or objects) when reinforcer delivery is withheld or terminated. According to Hutchinson, this general type of SIB may be related to phylogenetic factors, such as aggressive behavior that is protective. Clearly, when dangerous behavior such as self-biting begins to occur, it is conceivable that it enters into contingencies of reinforcement such as those described previously (e.g., Richman & Lindauer, 2005).

Pre-treatment Considerations for SIB

Before beginning a behavioral assessment, or perhaps during the behavioral assessment, there are several important considerations related to the occurrence of SIB. First, medical professionals should be consulted to evaluate whether self-injury is related in any way to a medical complication, pain, or state of physical discomfort (Bosch et al., 1997). If the root cause of SIB is related to a physiological variable, such as an ear infection or allergies, it is important that a thoroughgoing treatment would address all such variables. It is also possible that medical providers may prescribe medications to treat ailments (e.g., constipation) or other sources of discomfort (e.g., sleep deprivation). During the evaluation process, behavior analysts can assist by using reliable methods of data collection, both to provide objective measurement in their collaborations with other providers and ultimately to help measure treatment effects when a relation between a physiological variable and SIB has been identified.

Practitioners should also consider additional environmental modifications that may minimize injury risks, such as removing hard objects and padding furniture. In some cases, the severity of SIB may necessitate personal protective equipment such as helmets, arm guards, and gloves. Protective equipment may reduce the overall severity of SIB but also presents several potential

drawbacks. Protective equipment that limits motor movement has been associated with physiological side effects such as restricted range of motion, adverse effects on muscles and tendons, as well as bone degradation (e.g., Fisher et al., 1997). Thus, a careful balance between these negative side effects and client protection requires diligence and often coordinated efforts with a professional team. Additionally, in some cases, the protective equipment comes to function as a positive reinforcer for SIB and behavioral escalations may occur when the equipment is removed (e.g., Kahng et al., 2008). In these cases, practitioners must carefully weigh the benefits and drawbacks and plan for systematic fading of access to protective equipment as SIB is decreased. Protective equipment should not be viewed as an intervention per se, but rather as a possible necessity to ensure safety while a biobehavioral intervention is established.

Other safety precautions should be considered. Some aspects of behavioral assessment, such as functional analyses (discussed below), rely on being able to evoke SIB and, therefore, should not be conducted if SIB would cause immediate danger to the participant, such as in the case of pica (ingestion of inedible objects), blows to the head or eyes, or scratching that produces bleeding. Behavior-analytic services can be provided in a wide range of settings, but not all settings are equipped with the resources to support safe implementation of procedures to evaluate and treat SIB. For example, it might be safe to conduct a functional analysis of head banging in a hospital, where padding, helmets, and medical staff are readily available, but unsafe to conduct a functional analysis of head banging in a classroom at a school, where resources are more limited and dangerous materials may put an individual at risk (such as glass windows). During assessment and treatment sessions, medical personnel should also be consulted related to session-termination criteria. For example, some assessment sessions are terminated when a specific number of self-injurious responses have occurred, or when tissue damage is incurred (e.g., Lerman et al., 1994). When the individual's safety is at risk, and de-escalation techniques have been ineffective, crisis intervention programs may be required. Crisis intervention is distinct from behavioral intervention programs and generally involves physical management, sometimes including brief restraint, for the sole purpose of preventing the individual from further causing damage to themselves (Reed et al., 2013). These techniques should only be implemented by highly trained staff with ongoing supervision. Similar to protective equipment, crisis intervention programs are not a replacement for comprehensive medical or behavioral intervention and should not be implemented long-term (Reed et al., 2013; Vollmer et al., 2011).

Behavioral Assessment of SIB

Indirect Assessment

Indirect assessment refers to methods used to gather information about the target behavior via questionnaire or interview. During indirect assessments, informants are asked to provide descriptions of the behavior and information about common environmental events surrounding the target behavior. There are numerous indirect assessment formats available ranging from informal interviews to more structured interviews (e.g., O'Neill et al., 1997), questionnaires (e.g., Matson & Vollmer, 1995), and rating scales (e.g., Durand & Crimmins, 1988).

Generally, informants are asked about the environmental variables that co-occur with SIB. For example, in the Functional Analysis Screening Tool (FAST), informants are asked to provide a description of the topography, severity and frequency of the behavior, times when the behavior is most and least likely to occur, and "yes or no" answers to a series of questions (e.g., "Does the problem behavior occur when the person is asked to perform a task or to participate in activities?").

Indirect assessments are a useful component of any comprehensive behavioral assessment as they initiate a dialogue between the therapist and caregivers and provide a forum to collect preliminary information about SIB. For example, indi-

rect assessments can help in the development of objective descriptions of the target behavior (operational definitions) along with information about the frequency and severity of the SIB. Indirect assessments can also help identify potential medical or environmental variables that might affect either the specific function of SIB (e.g., menses might increase the likelihood of escape maintained problem behavior; Carr et al., 2003) or the rate of SIB more generally (e.g., sleep deprivation; Kennedy & Meyer, 1996). Other benefits of indirect assessments are that they can be administered relatively quickly (e.g., 15–20 min) and they require little training to conduct. Furthermore, indirect assessments may elucidate information about topographies that are not amenable to direct assessment methods. This may include behavior that occurs too infrequently to be reliably observed through direct assessment methods, covert SIB such as skin picking that occurs in the absence of other people, or responses that cannot be allowed to occur due to the severity of behavior (e.g., head banging against sharp objects, eye-gouging). Indirect assessments may provide a starting point to inform subsequent assessment components (e.g., descriptive and functional analyses) and may also provide an alternative when direct assessments cannot be conducted. However, in most cases, it is recommended that indirect assessments should not be used as the sole means to acquire information about SIB because they do not directly identify functional relations. Also, informant reports are widely known to be unreliable when indirect assessments are used to evaluate severe behavior (Roscoe et al., 2015). Thus, indirect assessments should be supplemented with direct assessment measures when possible.

Descriptive Analysis

Descriptive analysis (DA) refers to the direct observation of behavior during natural contexts (Bijou et al., 1968). During DAs, data are collected on the frequency or duration of the target behavior and surrounding antecedent and consequent events. However, as with indirect assessments, no systematic manipulation of consequences is made. Data gathered during DAs may provide necessary information for general assessment or treatment evaluation purposes such as operational definitions of behavior, baseline levels of responding, and potentially relevant environmental events. Another potential benefit of DA methods for SIB specifically is that direct observations of the topography might not only inform investigations of function but root cause as well. For example, if SIB is targeted at the jaw or mouth, it may be likely that the individual is experiencing dental pain that should be investigated. Similar considerations could be made for SIB directed at the ears (e.g., ear infections), stomach (e.g., gastrointestinal issues), or even head (e.g., headaches). Furthermore, DAs can be used to identify potential cyclical patterns in SIB that could be related to bio-behavioral factors such as allergies or menses (Carr & Smith, 1995).

The major limitation of DA methods is that a functional relation cannot be determined because consequences are not manipulated. For example, St. Peter et al. (2005) conducted functional analyses for four participants and found that attention was not a reinforcer for problem behavior for any of the participants. However, St. Peter et al. then used DAs to examine relations between attention and problem behavior and found that the delivery of attention was highly correlated with problem behavior for all participants. Thus, DA methods often indicate a relation between occurrence of problem behavior and the occurrence of attention, but that does not necessarily mean that attention is the reinforcer for the problem behavior. Additionally, several studies have compared the results from descriptive and functional analyses and found that often they do not correspond (see Contreras et al., in press, for literature review). Thus, DAs are generally determined to be inappropriate as a sole means of hypothesizing functional relations for SIB.

Despite limitations, DAs may inform functional analyses and treatments. For example, direct observation can improve operational definitions of behavior and provides information on the naturally occurring rates of behavior (i.e., a baseline), which can later be used to assess treat-

ment effects. They may also help to identify idiosyncratic events related to behavior (e.g., Schlichenmeyer et al., 2013), such as specific instructional demands associated with the behavior, or specific tangible or attention-related consequences. Furthermore, direct observation may provide useful information when functional analyses cannot be conducted safely. Descriptive analyses can also be used to identify precursors to more severe forms of behavior (Borrero & Borrero, 2008). These precursors identified via DAs can subsequently be reinforced, in lieu of SIB, in a functional analysis.

Functional Analyses

A functional analysis generally refers to the manipulation of variables to determine cause and effect relations. However, in the realm of contemporary applied behavior analysis, functional analysis usually refers to a specific assessment procedure used to identify reinforcers maintaining problem behavior (Iwata et al., 1994a). During a functional analysis, consequences are isolated and manipulated contingent on problem behavior to identify functional relations. Although the intentional delivery of potentially reinforcing events may seem counterintuitive, this approach is analogous to allergy testing, during which patients are exposed to various allergens to determine an effective course of treatment. During functional analyses, participants are exposed to analogs of situations they commonly experience in everyday life to determine an effective course of treatment. Functional analysis offers advantages over indirect and descriptive methods because the information gathered is not correlational. Thus, functional analyses may prevent the implementation of ineffective treatments or treatments that are contraindicated (e.g., Iwata et al., 1994b).

A commonly used functional analysis procedure was first described by Iwata et al. (1994a). The general procedures involved alternating the presentation of three test conditions and one control condition repeatedly in a multielement experimental design until clear outcomes were obtained. The purpose of the control condition was to create a situation in which SIB was unlikely to occur. That is, the participant was given free access to preferred items, the therapist provided attention intermittently, and no demands were placed on the participant. Differentially higher rates in the test conditions relative to the control condition were used to indicate a reinforcement effect. The test conditions in Iwata, Dorsey et al. included social attention, demand, and alone. In many current applications, another condition typically called "tangible" is included when necessary (Rooker et al., 2011).

The most common test conditions are alone/no interaction, attention, tangible, and escape (Beavers et al., 2013). Attention and tangible conditions test whether SIB is maintained by social positive reinforcement; a tangible or attention is initially withheld and only delivered contingent on SIB. The purpose of the escape condition is to test if behavior is maintained by socially mediated negative reinforcement in the form of escape, usually from instructional demands. The therapist presents the aversive stimuli (e.g., demands) and only removes them contingent on SIB. Differentially higher rates of SIB in these test conditions relative to the control condition indicate that SIB is reinforced by either access to attention, access to tangibles, escape from demands, or a combination.

The purpose of the alone or no-interaction condition is to test if behavior is sensitive to nonsocially mediated or automatic reinforcement. More specifically, this condition is used to evaluate whether SIB persists in the absence of social consequences. During the alone condition, the participant is left alone in the room and observed through a one-way mirror. During the no-interaction variation, the individual remains in the room with the therapist who provides no programmed consequences for SIB. Differentially higher rates of SIB in the alone or no consequence condition relative to the control condition indicate that SIB is automatically reinforced.

There are special considerations to consider when SIB is maintained by automatic reinforcement. Although high rates across all of the test and control conditions may in some cases indi-

cate that SIB is automatically reinforced because automatic reinforcement is available during any condition, there are other patterns that emerge. Thus, the pattern of responding in functional analyses can provide information about what treatment components may be necessary, which is discussed in the treatment section of this chapter. For example, Hagopian et al. (2015) analyzed functional analysis data for 39 individuals with SIB maintained by automatic reinforcement and identified three main subtypes of responding. Individuals with automatically reinforced SIB in subtype 1 engaged in the highest rates of SIB in the no-interaction condition and lowest rates of SIB in the play condition. For subtype 2, individuals engaged in high rates across all conditions. Patterns of behavior in subtype 3 resembled patterns in subtype 2, but SIB was accompanied by self-restraint (e.g., sitting on hands, putting arms inside of clothing).

When conducting functional analyses of SIB, several important considerations should be addressed. First, it should be determined whether the behavior is amenable to a functional analysis. Standard functional analyses should not be conducted if the behavior is classified as a restricted operant. For example, the probability of emesis (i.e., vomiting) decreases following the first instance, and thus within-session consequences designed to reinforce it may not produce a reinforcement effect. Relatedly, because clear functional analysis outcomes rely on at least moderate rates of behavior to assess relations between behavior and environmental events, functional analyses may be less useful for extremely low-rate SIB. In these cases, other assessment formats or variations of the standard functional analysis procedure should be used. Some limitations of functional analyses have been discussed in the literature, such as that they (a) require a specialized setting, (b) are time consuming and (c) are complicated to conduct (Roscoe et al., 2015). However, many variations in functional analysis have been developed to address these issues (e.g., brief functional analysis, evaluations of within-session responding, Querim et al., 2013). For more information on these variations, refer to Chap. 5 of this book.

Another consideration for the development of a functional analysis as an assessment component is that such an analysis may be inappropriate for some forms of behavior. For example, functional analyses may be inappropriate for behavior that causes an immediate danger to the participant, or behavior that occurs too infrequently to reliably observe. Variations in the standard functional analysis method have been proposed to address these limitations. For severe and dangerous forms of behavior, some researchers have suggested assessing less severe forms of precursor behavior that reliably precede SIB. For example, Smith and Churchill (2002) identified precursors for four individuals who engaged in SIB. They conducted functional analyses of both the precursor behavior and SIB and showed that the functions of the precursor behavior corresponded with the function of SIB. Other variations of functional analyses have been used to address the problem of low-rate behavior by increasing the duration of the test conditions from 10–15 to 45–60 min (Kahng et al., 2001).

In summary, functional analysis is considered standard in the behavioral assessment of SIB. Furthermore, previous research has shown that typical functional analysis procedures may be adapted to accommodate time constraints and other previously cited limitations. Functional analysis research or individualized functional analyses provide a direct link between assessment and treatment development.

Behavioral Treatment

When variables related to the occurrence of SIB have been identified, effective treatments can be developed. Function-based treatments that are designed to reduce SIB involve three primary components of intervention: antecedent or preventive environmental modifications, use of reinforcement to increase appropriate alternative skills, and consequence-based strategies (e.g., minimizing reinforcers for SIB, punishment procedures if reinforcement-based strategies alone are ineffective). Below we discuss treatment studies that usually isolate one of these compo-

nents. However, comprehensive, ethical, and effective treatments should aim to include multiple components.

Antecedent Interventions

Broadly, antecedent interventions are designed to arrange the environment to reduce the likelihood that target behavior occurs in the first place. These interventions often involve altering the environment to increase access to reinforcers and reduce or modify aversive stimuli that may evoke SIB. For example, if a student's SIB is evoked in the context of academic tasks in the classroom, some examples of antecedent interventions are physical alterations of the classroom to reduce noise (e.g., Kettering et al., 2018), instructional modifications to ensure work is at student's skill level (Reed et al., 2010), and choice of activities when possible (e.g., Humenik et al., 2008).

Another commonly used antecedent intervention is noncontingent reinforcement (NCR), or the time-based presentation of reinforcers independent of behavior (Carr et al., 2000). Noncontingent reinforcement decreases the occurrence of the target behavior by reducing the establishing operation controlling behavior (e.g., caregiver attention is already freely available, so there is less need to engage in SIB to get attention). Noncontingent reinforcement also weakens the contingency between the target response and reinforcer delivery, and (if SIB no longer produces the functional reinforcer) ensures that there is no programmed relation between the problem behavior and reinforcer delivery (Thompson & Iwata, 2005).

The NCR approach is commonly implemented using reinforcers identified via a functional analysis. In the treatment of severe SIB maintained by social positive reinforcement in the form of attention or tangibles, NCR involves the delivery of attention or tangibles continuously or at times independent of behavior (e.g., Vollmer et al., 1993). In the treatment of SIB maintained by social negative reinforcement in the form of escape from academic demands, NCR may involve providing brief escape from tasks at set intervals (e.g., a 30-s break every 2 min; e.g., Vollmer et al., 1995) or "free" positive reinforcers designed to reduce the aversiveness of the instructional activity (Lomas et al., 2010).

The NCR approach has also been shown to reduce socially reinforced SIB even when arbitrary or alternative reinforcers were used ("arbitrary" only in the sense that they were not the maintaining reinforcer for SIB). For example, if SIB is reinforced by access to attention, a caregiver may provide noncontingent access to alternative preferred tangible items. Similarly, if SIB is reinforced by escape from demands, providing alternative reinforcers such as preferred edibles or access to music during that demand period may reduce the SIB (e.g., Lomas et al., 2010). Phillips et al. (2017) analyzed 27 applications of NCR in the treatment of severe problem behavior. Notably, when the authors compared the effectiveness of functional vs. alternative reinforcers in NCR, results showed comparable reductions for socially reinforced problem behavior. Furthermore, a common and practical goal of behavioral intervention is to increase tolerance to delays to reinforcement or times when reinforcers are unavailable. NCR using alternative reinforcers has also been shown to maintain low levels of problem behavior during periods when the functional reinforcer is not available. Simmons et al. (2022) compared the effects of NCR during schedule thinning of the functional reinforcer for four individuals with ASD who exhibited problem behavior including SIB. The researchers signaled time periods when the functional reinforcer was not available and compared levels of problem behavior during control (no items/activities) versus when access to moderately preferred alternative items, moderately preferred attention, and moderately preferred tasks was provided. Results showed more effective and efficient schedule thinning when the participant was provided noncontingent access to alternative activities.

In the case of behavior reinforced by escape from demands, the inclusion of highly preferred reinforcers in an environment may reduce the motivation to escape the situation. Gover et al. (2019) conducted a review of 256 applications of

environmental enrichment to automatically reinforced problem behavior (including SIB). Results showed that EE alone reduced SIB to clinically appropriate levels in 44.6% of cases. EE plus an additional consequence manipulation reduced SIB to clinically appropriate levels in 56.1% of cases.

The application of NCR and EE is more effective when the items or activities used within them are identified via systematic assessment such as preference or reinforcer assessments (Vollmer et al., 1994). Preference assessments involve the presentation of various stimuli (e.g., toys, edibles) and direct observation of item selection and engagement, whereas reinforcer assessments test the efficacy of the stimulus at increasing a target response (see Kang et al., 2013 for a review). Conducting these assessments ensures that individuals will engage with the item, that the item functions as a reinforcer, or both. A similar assessment is the Competing Stimulus Assessment (CSA), which is a preassessment to identify items to include in NCR (e.g., Piazza et al., 1998). During CSAs, individuals are presented with stimuli, and data are collected on both item engagement and levels of problem behavior. Stimuli associated with high levels of engagement and low levels of problem behavior are then incorporated into treatment. CSAs have been effective at identifying competing items for a variety of functions of problem behavior (Haddock & Hagopian, 2020). In some cases, procedural modifications, such as prompting and reinforcement, may be necessary to increase engagement with potential competing items (e.g., Hagopian et al., 2020; Leif et al., 2020). Hagopian et al. conducted traditional CSAs and found that they were ineffective at identifying competing items for 6 participants who exhibited SIB. They re-presented the items and implemented prompting for item engagement and response blocking for SIB. The augmented CSA effectively identified items for all 6 participants.

Noncontingent reinforcement, and related, procedures have several important advantages. First, continuous access to functional or alternative reinforcers provides a powerful intervention to greatly reduce SIB. For this reason, continuous NCR may be indicated as a first step when the safety of the individual is in danger. Second, NCR is relatively easy to implement because reinforcers are delivered based on time (rather than observation of behavior). Thus, therapists do not need to constantly attend to the individual in order to implement the procedure correctly. Third, NCR is effective across a range of functions and topographies.

Noncontingent reinforcement is associated with at least three main disadvantages. First, NCR does not specifically promote adaptive behavior. For that reason, NCR should be considered just one component of an effective behavioral intervention including differential reinforcement of alternative behavior. Second, NCR may compete with other schedules of reinforcement. For example, Goh et al. (2000) showed that dense schedules of NCR decreased SIB to low levels but interfered with the participants' acquisition of mands for the functional reinforcer. The schedule of NCR had to be thinned before manding emerged. Although continuous or dense schedules of NCR may be necessary early in treatment to reduce SIB to safe and manageable levels, these schedules should be thinned to avoid interference with development of adaptive skills. Third, on rare occasions, NCR may strengthen problem behavior as a result of accidental pairings between behavior and reinforcer delivery (e.g., Vollmer et al., 1997). This problem can be addressed by including a momentary differential reinforcement of other behavior (mDRO) component, or brief temporal gap before reinforcer delivery, to ensure that the SIB and reinforcer are not coupled on a consistent basis (e.g., Lindberg et al., 1999).

Increasing Appropriate Alternative Skills

The second main component of a comprehensive function-based treatment is increasing appropriate alternative skills. Behavior analysts recognize that SIB occurs as a function of environmental consequences, and simply targeting SIB for reduction without teaching the individual new

ways to access reinforcers would be unethical. Appropriate alternative skills are often strengthened via differential reinforcement of alternative behavior (DRA). During DRA, reinforcers are provided at greater levels (i.e., along at least one dimension) for alternative skills and reinforcers are minimized for problem behavior (Vollmer et al., 2020). As a result, problem behavior is reduced by strengthening specific responses to compete with the target response.

One variant of DRA is *functional communication training* (FCT). In FCT the alternative behavior takes the form of a conventional communication response and can be used to obtain the same reinforcer previously maintaining problem behavior (Carr & Durand, 1985; Durand & Carr, 1991). The form of the appropriate behavior may be determined by considering the abilities of the student (in terms of their existing communicative repertoire) and the readiness of the community to respond appropriately to the communicative response. In general, the response effort to engage in the functional communication response should be low, and the schedule of reinforcement should, at least initially, be continuous until the individual is exhibiting the skill regularly and across environments (Tiger et al., 2008).

As a treatment to reduce problem behavior reinforced by social positive reinforcement (in the form of attention or access to tangibles), FCT involves teaching the individual how to request and then providing attention or tangibles following each appropriate request. Likewise, to reduce problem behavior reinforced by social negative reinforcement (in the form of escape from task demands), FCT would consist of providing a momentary reprieve from the work materials. For example, if the individual were to sign "break" during an instructional sequence, the therapist might quickly remove the task materials and turn away from the individual for 30 s. Marcus and Vollmer (1995) investigated the use of DRA to reduce a girl's disruptive behavior reinforced by social negative reinforcement in the form of escape from demands. In one condition, breaks were provided following appropriate requests. In another condition, breaks were provided following compliance with the academic demands. Both conditions produced decreases in disruptions; however, compliance remained low in the condition in which requests were reinforced by a break and compliance increased in the condition in which breaks were provided following compliance. Thus, it is important at times to consider DRA procedures that do not necessarily reinforce communication per se but that target some other specific replacement behavior. Most published treatment evaluations of DRA have used the procedure in conjunction with extinction for problem behavior. That is, appropriate alternative responses were reinforced on dense schedules while reinforcers were withheld for problem behavior. For several reasons, however, extinction for problem behavior may not be advised.

A DRA approach offers certain advantages when extinction is not a viable treatment component. First, DRA may be implemented with alternative reinforcers which compete with the functional reinforcers for self-injury. For example, several studies have shown that positive reinforcement for compliance may decrease escape-maintained problem behavior and increase compliance, even as problem behavior continues to be reinforced with breaks from demands (e.g., Carter, 2010; Slocum & Vollmer, 2015). Second, DRA may be implemented by altering parameters of reinforcement such as quality, amount, delay, and ratio-requirement for both problem and appropriate behavior in a way to favor appropriate behavior (e.g., Athens & Vollmer, 2010; Kunnavatana et al., 2018). Baum (1974) described the matching law, a quantitative description of behavior that can account for variations in reinforcement parameters. The matching law predicts that, in situations in which two responses are available (e.g., problem and appropriate behavior), more behavior will be allocated toward the response associated with higher frequencies, higher quality, higher quantity, and lower delays to reinforcement. When applied to problem behavior, if a care provider must present attention following problem behavior (e.g., SIB that would produce immediate tissue damage), the parent could provide brief, lower quality attention following SIB (e.g., minimal physical guidance or blocking) compared to following

appropriate requests (e.g., high levels of verbal praise, high fives, special toys, or treats). For less serious problem behavior, delays and ratio-requirements could also be manipulated. For example, a parent might only provide attention following a brief delay after every other instance of problem behavior as compared to providing attention immediately after every instance of appropriate behavior. Kunnavatana et al. assessed participants' sensitivity to or preference for the different parameters and used the results to implement differential reinforcement in the treatment of problem behavior. Results showed that when both problem behavior and appropriate behavior resulted in the same consequence, participants exhibited high rates of problem behavior. When appropriate behavior resulted in higher magnitude or higher quality reinforcers, problem behavior decreased to zero levels.

In addition to the advantages described above, DRA specifically arranges for the strengthening of appropriate behavior while reducing competing inappropriate behavior. Effects of DRA in the form of FCT may also be more likely than effects of other procedures to persist outside of the treatment environment if the communicative response is likely to produce the maintaining reinforcer in other environments (such as with the use of conventional speech). One disadvantage of DRA, at least in the form of FCT, is that for some individuals, a punishment component is sometimes necessary (e.g., Hagopian et al., 1998; Hanley et al., 2005; Rooker et al., 2013). However, the need for punishment procedures may be mitigated when additional supports such as visual cues are implemented (e.g., Greer et al., 2016).

Another DRA approach is to "treat" SIB by building a wide range of replacement skills via reinforcement procedures including shaping, chaining, and modeling. The notion is that the more extensive the adaptive repertoire, the less time an individual has to engage in SIB. This approach targets specific skills or sets of skills, not as a direct functional replacement for SIB, but rather on the premise that the ability to communicate generally, engage in appropriate leisure activity, and engage in work or academic ability in some way supplants the likelihood of engaging in SIB. The approach is consistent with basic research on the matching law, which suggests that individuals allocate their behavior toward reinforcers that are more frequent and easier to obtain. One form of the matching law, single-alternative matching (de Villiers, 1977), describes the relation between engaging in one response, the reinforcers available for that response, engaging in all other responses, and all other available reinforcers. For individuals who engage in SIB, response allocation may be considered a "choice" between engaging in SIB and engaging in anything else (the term choice is used here in a technical sense and is not intended to imply that the individual wants to engage in SIB). From the perspective of the matching law, a person may be less likely to engage in SIB if reinforcers for other behavior are more readily available. It follows then that SIB (or other forms of severe problem behavior) may be suppressed by teaching individuals new ways of obtaining reinforcement. That is, by increasing the reinforcers available for "doing anything else," the relative payoff for engaging in SIB will be reduced.

When SIB is evoked by the presentation of certain environmental stimuli (e.g., instructional demands, medical/dental procedures, noise), then systematic fading, desensitization of the stimuli, or both, may be useful. Initially, stimuli that evoke SIB are removed from the environment and then gradually introduced as SIB remains low. Reinforcers are provided for the absence of SIB or contingent upon appropriate alternative behavior, such as compliance with instructions. Stuesser and Roscoe (2020) compared the effects of differential reinforcement and differential reinforcement plus stimulus fading in the treatment of problem behavior maintained by escape from medical exams. Results showed that stimulus fading, conducted by breaking down exams into smaller components and introducing them gradually, was necessary to increase compliance and reduce problem behavior. In another example, Ricciardi et al. (2006) evaluated contact desensitization to treat a phobia (i.e., screaming, aggression, elopement) to animatronic objects exhibited by an 8-year-old with ASD. They initially provided noncontingent access to preferred

activities 6 m away from the target object. Then they gradually decreased the proximity to the target object to maintain reinforcer access. The treatment package was effective at decreasing problem behavior and increasing approaches to the animatronic object, even in the absence of extinction procedures.

Consequence-Based Strategies

Treatment plans should also specify what to do when the target behavior occurs. Procedurally, extinction involves withholding reinforcers that were previously delivered following behavior (Catania, 1998). Extinction results in a gradual decrease in the likelihood of behavior (Skinner, 1938). In addition to the gradual decrease in behavior (main effect of extinction), the procedure is also commonly associated with potentially adverse side effects sometimes collectively referred to as an extinction burst (Lerman & Iwata, 1996). These side effects may include temporary increases in rate and intensity of the target behavior as well as aggression and an increase in topographical variations of self-injury (including both novel and previously reinforced forms). Additionally, a number of factors may lead to the reemergence of previously extinguished self-injury including changes in environmental context, also known as renewal (e.g., Muething et al., 2020) or extinction of or decreases in reinforcement schedules for alternative behavior, also known as resurgence (e.g., Wacker et al., 2013).

Therefore, extinction should rarely, if ever, be used in isolation. More commonly it is used as a component within a larger treatment package. The specific form of the extinction procedure may appear different depending on the source of reinforcement being withheld (Iwata et al., 1994b). For example, extinction of behavior maintained by social positive reinforcement in the form of attention would likely involve minimizing attention toward the individual following instances of SIB (e.g., Iwata et al., 1994b). Conversely, extinction of SIB maintained by social negative reinforcement in the form of escape from instructional activities would involve continued presentation of the instructional activity following problem behavior (e.g., Iwata et al., 1990). In either case, extinction necessitates that the reinforcers no longer follow behavior.

When reinforcement for SIB is socially mediated, with the exception of situations in which safety prohibits it, it is usually possible for the care-provider to at least minimize reinforcement. However, when SIB is automatically reinforced it is more difficult to withhold reinforcement because the reinforcement is not directly controlled by a care-provider. Nonetheless, the procedure known as "sensory extinction" provides a model for extinction of automatically reinforced behavior (Rincover, 1978). For example, Iwata et al. (1994b) implemented extinction of one individual's head banging by placing a helmet on the individual's head. Rates of SIB decreased markedly when the helmet was worn. Presumably, the helmet served to attenuate the sensation caused by head banging because the individual was still able to engage in the response (and did, initially) while only the products of the response changed. Therefore, the behavior decreased when its reinforcing consequences were no longer available. Similar effects have been reported with gloves (for hand biting) and other protective equipment (e.g., Roscoe et al., 1998).

Because extinction in isolation is rarely recommended, practitioners should include a plan for the individual to access reinforcement in another manner. In addition to NCR and DRA procedures, differential reinforcement of other behavior (DRO) involves the delivery of reinforcers for the absence or non-occurrence of behavior for a set time period. For example, if SIB is maintained by access to tangibles, then tangible items can be delivered every 5 min as long as SIB has not occurred. One potential advantage of DRO is that, when combined with extinction, it may attenuate some of the potential side effects of extinction (Homer & Peterson, 1980). That is, unlike with pure extinction, the individual still has some access to the reinforcer. However, DRO has been associated with aggression (Lennox et al., 1987) and emotional behavior (Cowdery et al., 1990). Differential reinforcement of other

behavior has other noteworthy disadvantages. For example, the procedure may result in low rates of reinforcement if rates of the target response remain high. In such cases, DRO is functionally equivalent to extinction and in turn may produce side effects similar to the extinction burst (Vollmer et al., 1993). Additionally, DRO does not explicitly promote appropriate alternative behavior. Although appropriate behavior may indeed occur during intervals in which SIB does not occur, the procedure neither ensures that appropriate behavior occurs or that other inappropriate behavior does not occur during reinforced intervals (e.g., Jessel et al., 2015). When alternative reinforcers are used (as is often the case with behavior maintained by automatic reinforcement), DRO may be less effective because the success of the intervention depends on the ability of these reinforcers to compete with the reinforcers maintaining problem behavior (Carr & Durand, 1985; Cowdery et al., 1990).

In some cases, the severity of SIB (including resistance to treatment) may necessitate additional behavior reduction procedures. Punishment is the suppression of behavior as a result of the presentation or removal of stimuli following behavior (Miltenberger, 2008). While both punishment procedures have been used historically, they should be considered a last resort to intervention. At times it may be considered unreasonable or unethical to continue to implement an ineffective treatment when other procedures (i.e., punishment procedures) could be effective. Perhaps the most severe and intractable cases of dangerous SIB could be immediately suppressed via punishment, while other (more widely accepted) treatments could be incorporated. Of course, careful peer review and proper ethics training would be a prerequisite to usage of punishment procedures, or for that matter any procedures designed to reduce dangerous SIB.

Conclusion

Self-injury is a dangerouss form of behavior that occurs in some individuals diagnosed with ASD. A majority of evidence supports the notion that SIB is, at least in part, learned behavior. Behavioral assessment methods are designed to identify reinforcers maintaining SIB so that more effective treatments can be developed. Although assessment components have advantages and disadvantages, collectively the idea is to link the assessment information directly to treatment development. The most effective treatments involve multiple antecedent and consequent components to reduce motivation to engage in SIB and to promote functional and pivotal alternative behavior. It is important to consider the overall skill repertoire of the individual and to teach replacement behavior even if it is not directly or functionally related to SIB. In addition, although controversial, there may be some severe cases where punishment should be considered in the best interest of the individual. In any case of dangerous SIB, peer review is recommended so that the decision-making process of the practitioner is suitably aided by input from colleagues.

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