PERGAMON

Journal of Behavior Therapy
and Experimental Psychiatry 31 (2000) 137–154

JOURNAL OF
behavior
therapy
and
experimental
psychiatry

www.elsevier.com/locate/jbtep

Recent advances in the assessment of aberrant behavior maintained by automatic reinforcement in individuals with developmental disabilities

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Received 5 November 1999; received in revised form 14 August 2000; accepted 13 September 2000

Abstract

Many aberrant behaviors exhibited by individuals with developmental disabilities are maintained by "automatic reinforcement". These behaviors are often difficult to treat, with the most effective behavioral interventions often resulting in only moderate success. However, a series of recent studies has advanced our ability to understand and treat these behaviors through the innovative use of behavioral assessment. We review the recent development of three categories of assessments: (a) nonhypothesis-based stimulus preference assessments, (b) hypothesis-based stimulus preference assessments, and (c) hypothesis-based assessments incorporating noncontingent reinforcement and sensory extinction procedures. We consider each category's contribution to both our ability to prescribe effective behavioral interventions and our ability to more fully understand the concept of automatic reinforcement.

Keywords: Automatic reinforcement; Developmental disabilities; Functional assessment; Pica; Stereotypy; Preference assessment; Noncontingent reinforcement; Sensory extinction

B. F. Skinner (1953) used the term *automatic reinforcement* to refer to the maintaining variable(s) for operant behaviors whose reinforcers are not mediated by the social environment. For these behaviors, the maintaining reinforcer is a direct result of the behavior (Vaughan & Michael, 1982). If these direct consequences function to increase

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0005-7916/00/$ - see front matter
PII: S0005-7916(00)00017-3

behavior, they may result in automatic positive reinforcement (e.g., singing to yourself to produce auditory stimulation) or automatic negative reinforcement (e.g., scratching your arm to alleviate an itch).

For several decades, the concept of automatic reinforcement has been applied to the classification of certain aberrant behaviors exhibited by individuals with developmental disabilities (Shore & Iwata, 1999). The development of the experimental functional analysis has improved our ability to determine which variables maintain aberrant behavior by presenting and withdrawing stimuli in a controlled setting and observing corresponding behavioral changes (Iwata, Dorsey, Slifer, Bauman, & Richman, 1994, reprinted from 1982). Recently, Iwata et al. (1994) reported an epidemiological study of 152 functional analyses of self-injurious behavior (SIB). The authors reported that approximately one-fourth of the functional analyses resulted in a pattern consistent with a hypothesis of automatic reinforcement (these patterns are discussed in more detail below in Section 1.

Vollmer (1994) discussed the difficulty in treating aberrant behavior maintained by automatic reinforcement. Interventions for socially mediated aberrant behavior usually address the function of the behavior in the course of treatment. Common function-based interventions may include extinction, differential reinforcement, noncontingent reinforcement (NCR), or a combination of these interventions (Carr, Coriaty, & Dozier, 2000). When the maintaining variable is not socially mediated and/or not specifically identified, many of these function-based treatments become more difficult or impossible to implement. Instead, the clinician must rely on two categories of interventions: punishment and stimulus competition. Punishment involves the presentation of aversive stimulation that merely overpowers the automatic reinforcer produced by the response (Shore & Iwata, 1999). Interventions based on stimulus competition place an arbitrarily chosen stimulus in competition with the concurrently available functional reinforcer. Stimulus competition can be contrasted with stimulus substitution, in which a new stimulus is directly substituted for the functional reinforcer (thus, eliminating the concurrent choice between two qualitatively different reinforcers).

Environmental enrichment (EE) is a common example of an intervention that is based on stimulus competition. Several reviews of the treatment literature have indicated that interventions based on stimulus competition have been only modestly effective in reducing aberrant behavior. LaGrow and Repp (1984) reviewed several treatment studies on stereotypic responding and found that EE was effective in only five of the seven studies in which it was employed. In many studies, EE resulted in only moderate decreases in aberrant behavior and sometimes actually increased stereotypic responding when objects or social interactions were introduced. The authors concluded that "increased environmental or social interaction alone is not enough to reduce" stereotypic behavior (p. 598).

Historically, one of the most common decelerative interventions for aberrant behavior has been differential reinforcement (Lennox, Miltenberger, Spengler, & Erfanian, 1988). In early investigations, differential reinforcement procedures were often reported as effective (e.g., Repp, Deitz, & Deitz, 1976); however, there were also reports of ineffectiveness (e.g., Denny, 1980; LaGrow & Repp, 1984). Other literature

reviews have confirmed the variable effectiveness of these interventions with automatically reinforced aberrant behavior and have discussed the need to predict the conditions under which differential reinforcement procedures might be effective (Shore & Iwata, 1999; Vollmer, 1994). Consequently, the first purpose of the current article is to review the development of assessment methods that enhance both treatment effectiveness and prescriptive ability in the treatment of automatically reinforced aberrant behavior.

Kennedy (1994) delineated two uses of the term *automatic reinforcement*. He contended that the term has served as an explanation for behavioral function in the absence of an experimental demonstration and that this use of the term should be avoided. The second and more helpful use of the term denotes the presence of behavior that is maintained independent of the social environment. This usage suggests "the need for new hypotheses and experimental analysis" to more accurately determine the specific reinforcers for automatically maintained behavior (p. 392). In the last five years, a number of investigations have furthered our understanding of behaviors maintained by automatic reinforcement and enhanced our ability to treat these behaviors. The advances were due to the development and refinement of assessment procedures rather than the development of revolutionary new treatment procedures. The second purpose of this article is to review the impact of recent advances in assessment technology on our understanding of aberrant behavior maintained by automatic reinforcement. The final purpose of the paper is to discuss potential future directions for this line of research.

1. Methods for identifying automatically reinforced aberrant behavior

As mentioned above, functional analyses have been used to generate and test hypotheses about the variables that maintain aberrant behavior (Iwata et al., 1994, reprinted from 1982). Throughout the current article, we use the term automatic reinforcement to refer to behavior that resulted in one of the following functional analysis patterns. Other researchers have used the phrases "maintained independent of social consequences", "maintained independent of the social environment", and "nonsocially mediated" when referring to the same phenomena. In functional analyses, several response patterns are typically interpreted as indicative of automatic reinforcement (Hagopian et al., 1997). First, a differentially high rate of responding in the alone or no-interaction condition (with low rates in attention, demand, and play conditions) is considered indicative of automatic reinforcement. Second, a pattern of high and variable rates of responding in all conditions is also considered indicative of automatic reinforcement. Finally, higher rates in conditions with low stimulation (e.g., alone, low attention), and lower rates in conditions with greater stimulation (e.g., demands, control/play) may also indicate automatic reinforcement. Functional analyses that are conducted using multielement designs may produce carryover (interaction) effects or intermittent social reinforcement schedules which result in a pattern of responding that erroneously indicates automatic reinforcement (Vollmer, Iwata, Duncan, & Lerman, 1993).

Vollmer, Marcus, Ringdahl, and Roane (1995) suggested that any functional analysis that produces the results described above should be followed by a more extensive analysis to eliminate the possibility of social maintaining variables. Social attention is perhaps the most difficult variable to eliminate because the relevant establishing operation (i.e., attention deprivation) is present in both the attention condition and the alone condition. However, in the alone condition there is no discriminative stimulus (e.g., the presence of a therapist) and no delivery of attention contingent on aberrant behavior. Vollmer et al. suggested that (a) a series of extended alone or no-interaction sessions or (b) the use of a reversal instead of a multielement design is likely to eliminate the potential confound of carryover effects from attention sessions. Extended alone or no-interaction sessions may also mitigate, but not eliminate, the possibility that an *intermittent* schedule of social reinforcement maintained responding. In two separate studies, these additional analyses were conducted, and the experimenters were able to identify social reinforcers as maintaining variables for 20–50% of functional analyses that were initially thought to be indicative of automatic reinforcement (Vollmer et al., 1993; Vollmer et al., 1995). Although these methods rule out social reinforcers as maintaining variables, they do not specifically identify the functional reinforcer beyond the category of automatic reinforcement. Thus, we have no information about the specific reinforcing properties of the behavior, and no information regarding treatment prescription.

Since 1994, a number of studies have examined the utility of different assessment techniques for evaluating automatically reinforced aberrant behavior. The three assessment categories that will be discussed in this article are (a) nonhypothesis-based stimulus preference assessments, (b) hypothesis-based stimulus preference assessments, and (c) hypothesis-based assessments that utilize NCR and sensory extinction procedures. Each of these methods has added either specific prescriptive information about the potential effectiveness of a given treatment, or specific information about the potential reinforcing properties of an aberrant behavior. Again, the information provided by these assessments has improved treatment, not in the development of new interventions, but in the identification of stimuli to use within traditional interventions (e.g., differential reinforcement).

2. Nonhypothesis-based stimulus preference assessments

Each study discussed in this section examined the role of stimulus preference in the effectiveness of either an EE or a differential reinforcement intervention. The stimuli that were included in the preference assessments were not hypothesized to be associated with the source of reinforcement produced by the aberrant behavior. Instead, these stimuli were appropriate leisure items that could be easily delivered to the participant. The premise of each study was that only highly preferred stimuli would be expected to compete with the source of automatic reinforcement, which would be concurrently available throughout the intervention. In previous treatment analyses, stimuli used in treatments were not identified with preference assessments and may not have been highly preferred (Vollmer, 1994). Thus, the following assessments

attempted to provide a more precise means of predicting the potential effectiveness of common interventions for automatically reinforced aberrant behavior.

Vollmer, Marcus, and LeBlanc (1994) examined the effectiveness of EE packages in decreasing the automatically reinforced SIB of three preschool children with developmental delays. The authors sought to enhance the effectiveness of a standard EE procedure by incorporating the results of a recently developed paired-stimulus (forced-choice) preference assessment (Fisher et al., 1992). In this procedure, each item was presented in direct comparison with each other item, and the child was asked to "pick one" per trial. The preference score for each item was based on the percentage of trials each item was chosen. The authors hypothesized that the most preferred items might effectively compete with the source of reinforcement produced by SIB when concurrently available in an enriched environment. For two of the three participants, EE was effective when highly preferred stimuli were available and was less effective when the stimuli were less preferred. For a third participant, EE was somewhat effective when highly preferred stimuli were available, but moderate rates of SIB persisted until a contingent hands-down/time-out procedure was applied. The data for the third participant demonstrate the difficulties that may arise when interventions rely solely on stimulus competition (i.e., competition between programmed and functional reinforcers). This study illustrated the use of stimulus preference assessments to enhance the effectiveness of EE procedures. The study also illustrated many of the difficulties (e.g., client idiosyncrasies, preference changes) associated with establishing competing schedules of reinforcement between aberrant and appropriate behavior.

Piazza, Fisher, Hanley, Hilker, and Derby (1996a) also used a stimulus preference assessment to enhance the treatment of automatically reinforced aberrant behavior. In this preliminary investigation, the authors examined the rate of aberrant behavior in relation to the amount of engagement/orientation with each item during a single-stimulus preference assessment. Each of several items was presented individually for a 30 s interval while two measures were collected: stimulus interaction (duration) and SIB (frequency). The authors then attempted to predict the effectiveness of differential reinforcement of other behavior (DRO) using stimuli from three categories: (a) high preference/high SIB, (b) low preference/low SIB, and (c) high preference/low SIB. Stimuli from the first category resulted in increases in SIB when provided in a DRO procedure. Stimuli from the second category produced no changes in the rate of SIB. Stimuli from the third category proved effective reinforcers for a simple motor response (e.g., head turning), but did not prove effective when used in a DRO procedure for SIB. This study is important for at least two reasons. First, the authors directly measured and compared item engagement and aberrant behavior. Second, the authors demonstrated that the mere presentation of "preferred" stimuli, even within a DRO procedure, was no guarantee of successful behavior reduction. Although the effects were inconclusive and the mechanisms responsible for the effects were not identified, the authors did identify a potentially important consideration. That is, when treating automatically reinforced behaviors, it might be advantageous to determine the correlation between certain stimuli and aberrant behavior before subsequently using those stimuli in behavior-reduction procedures.

In the aforementioned study by Piazza et al. (1996a), the authors reported different measures (duration and frequency) for the two behaviors of interest, prohibiting any direct comparison of behavioral levels. In their study, comparisons were made between the relative ranks of both measures instead of their absolute values. Ringdahl, Vollmer, Marcus, and Roane (1997) addressed this measurement difficulty when they developed a stimulus preference assessment procedure that used the same dependent measure for both stimulus interaction and aberrant behavior. During their free-operant preference assessment, multiple stimuli were available and partial-interval data were collected on the percentage of 10 s intervals during which the participants interacted with each item, engaged in SIB, or exhibited both behaviors. The authors compared the results of the 10 min stimulus preference assessment session to the average percentage of intervals containing aberrant behavior during a baseline session when no stimuli were available. The results allowed prediction of the effectiveness of the stimuli in EE and differential reinforcement interventions. For example, one participant's SIB occurred at consistent rates across each 10 min session indicating that the presence of preferred stimuli had no effect on SIB. Consequently, the authors predicted that an EE package would not reduce aberrant behavior. However, at least one stimulus resulted in high rates of engagement indicating that this stimulus might function effectively in a DRO or DRA procedure. A subsequent treatment analysis indicated that the predictions were correct for this participant with EE proving to be an ineffective intervention and a combined DRO/DRA procedure effectively reducing SIB. For other participants, SIB decreased in stimulus preference assessment sessions, indicating that an EE package might effectively reduce SIB. Subsequent analyses demonstrated the effectiveness of the EE package. Thus, this study provides evidence that stimulus preference assessments can directly assist in treatment prescription.

Shore, Iwata, DeLeon, Kahng, and Smith (1997) suggested that the manipulation of preferred stimuli could be conceptualized in terms of stimulus competition or substitution. The authors demonstrated that the extent to which object manipulation competed with SIB (i.e., high engagement/low SIB) predicted the effectiveness of an EE package, but did not predict the effectiveness of a differential reinforcement intervention. In the first experiment, the authors continuously provided stimuli (high engagement/low SIB) in an enriched environment with no social interaction and compared this condition to a baseline condition with no stimuli. For each of three participants, responding shifted almost exclusively from SIB to object manipulation indicating that (a) SIB and item engagement were competing or substitutable reinforcers and (b) an EE intervention using these items could be effective in reducing SIB. A second experiment examined the effectiveness of leisure items when used in a DRO intervention with varying criteria for and durations of reinforcement. The DRO intervals ranged from 5 to 60 s and the reinforcer duration ranged from 15 to 60 s with varying combinations of the intervals in different phases. DRO was ineffective in reducing the SIB of any participant in any combination of intervals indicating that these items were ineffective when made available contingent upon the absence of SIB. Although a clear preference for these items was evident when both objects and SIB were concurrently available, the preference was "abolished by requiring individuals to refrain from engaging in SIB for even brief periods" (p. 31). In a final experiment, the

authors manipulated the effort required to access leisure items by placing them at differing distances from the participant. Thus, the participants had to alter their reclined position to reach the items. This manipulation demonstrated the fragility of the participants' initial preference for the leisure items over SIB.

Each of the four studies reviewed above may contribute to our ability to effectively treat automatically reinforced aberrant behavior. The treatment advances have not resulted from the development of new interventions. Instead, they have resulted from the use of stimulus preference assessments to guide the selection of common behavioral interventions such as EE and differential reinforcement. While these studies demonstrate that interventions can be enhanced through behavioral assessment, the next two groups of studies enhance our ability to more specifically pinpoint the source of automatic reinforcement.

3. Hypothesis-based assessments

One of the first hypothesis-driven interventions for behaviors maintained by automatic reinforcement was "sensory extinction" (e.g., Rincover, 1978; Rincover, Cook, Peoples, & Packard, 1979; Rincover, Newsom, & Carr, 1979). Rincover posited that masking the sensory consequences hypothesized to maintain a behavior would result in extinction. He first demonstrated sensory extinction with an individual who frequently spun plates on tabletops. Rincover hypothesized that the maintaining reinforcer was auditory stimulation, so he masked the auditory stimulation produced by the plate and the behavior subsequently decreased. Another early approach at hypothesis-based intervention was presented by Favell, McGimsey, and Schell (1982). The authors provided participants with noncontingent tangible stimuli that presumably substituted for the sensory stimulation produced by the target behaviors. Pica and hand mouthing fell to near-zero levels when participants were given rubber toys and eye poking also decreased after alternate visual stimulation was presented.

These early studies have directly affected recent efforts at evaluating hypotheses about the potential reinforcing properties of aberrant behavior. These studies of sensory extinction and alternative sensory stimulation are particularly important to the treatment literature because they were the first to address the specific putative reinforcers for automatically reinforced aberrant behavior. Although Rincover (1978) and Favell et al. (1982) did not use specific functional assessment procedures, the authors did provide a conceptual framework for current researchers to treat automatically reinforced behaviors through hypothesis development. Recent researchers have extended this line of research by incorporating either stimulus preference assessments (see Table 1) or NCR and sensory extinction assessments (see Table 2) to test hypotheses about the specific nature of the reinforcer for aberrant behavior before treatment selection.

3.1. Stimulus preference assessments

In one recent study, Goh et al. (1995) examined the reinforcing properties of hand mouthing in several individuals diagnosed with profound mental retardation. Initial

Table 1
Summary of studies that employed hypothesis-based stimulus preference assessments[a]

Author(s) & year	*n*	Primary participant diagnosis	Behavioral topography	Hypothesis of behavioral function	Resulting intervention(s)
Goh et al. (1995)	9	Profound MR	Hand mouthing	Hand stimulation	Noncontingent access to toys, noncontingent access plus punishment (equipment, response cost)
Piazza et al. (1996b)	1	Autism, severe MR	Pica of cigarette butts	Access to tobacco	Noncontingent access to food plus response interruption
Piazza et al. (1998)[b]	3	Profound MR, severe MR and autism, autism, ADHD, moderate MR	Pica	Oral stimulation	Noncontingent access to food, noncontingent access to food and mouthing items plus response blocking
Piazza et al. (2000)[c]	3	ADHD and severe MR, ADHD and severe MR, profound MR	Dangerous acts (jumping from high places), saliva play, hand mouthing	Kinesthetic stimulation, manipulation of viscous substance, oral or hand stimulation	Noncontingent access to ball, noncontingent access to mirror/shaving cream, noncontingent access to food or massager

[a] ADHD = Attention-deficit/hyperactivity disorder; MR = mental retardation.
[b] Piazza et al. (1998) employed NCR as a hypothesis-based assessment procedure in one phase (Exp. 4).
[c] Piazza et al. (2000) employed NCR as a hypothesis-based assessment procedure in the final phase.

Table 2
Summary of studies that employed noncontingent reinforcement and sensory extinction as hypothesis-based assessments[a]

Author(s) & year	*n*	Primary participant diagnosis	Behavioral topography	Hypothesis of behavioral function	Resulting intervention(s)
Fisher et al. (1998)	2	Moderate MR, autism	Property destruction, stereotypy	Destruction of materials	Noncontingent access to matched stimuli, response blocking
Kennedy and Souza (1995)	1	Profound disability, visual impairment	SIB	Visual stimulation	Noncontingent and contingent access to a video game
Patel et al. (2000)	2	Autism, severe MR	Stereotypy, SIB	Auditory, tactile stimulation	DRO using stimuli within the hypothesized sensory classes
Rapp et al. (1999)	1	Severe MR, mild cerebral palsy	Hair pulling and manipulation	Digital-tactile stimulation	No treatment data presented
Sprague et al. (1997)	2	Severe MR, legal blindness, moderate hearing impairment	Stereotypy, SIB	Auditory, tactile stimulation	Contingent presentation of selected stimuli plus response interruption
Wilder et al. (2000)	1	Profound MR, visual impairment	Stereotypy	Tactile, kinesthetic stimulation	Noncontingent access to vibratory stimuli

[a]DRO = differential reinforcement of other behavior; MR = mental retardation; SIB = self-injurious behavior.

functional analyses indicated that hand mouthing was maintained by social positive reinforcement for two of the 12 participants. The hand mouthing of the remaining 10 participants was maintained by automatic reinforcement. In a subsequent experiment, the authors attempted to identify the specific reinforcing properties of hand mouthing for each participant. The authors suggested that the behavior of hand mouthing could result in at least two types of stimulation that might maintain the behavior: hand stimulation or oral stimulation. The authors attempted to evaluate preference for each type of stimulation by observing hand mouthing, hand–toy contact, and mouth–toy contact while each of several stimuli were presented in a single-stimulus presentation format. Items that occasioned either hand–toy or mouth–toy contact were each made freely available (one per trial). The authors propose that individuals would use items to provide stimulation to either the hand or mouth depending on which type of stimulation was more desired. The results indicated that hand stimulation occurred in the greatest percentage of intervals for most participants. However, the results differed slightly for each individual indicating the importance of individual assessment of the important components of the aberrant behavior.

The study by Goh et al. (1995) was particularly important for two reasons. First, the authors attempted to pinpoint the source of reinforcement more specifically than had been attempted before. Second, the authors provided an interesting and useful methodology for concurrently assessing aberrant behavior and engagement with other items. This methodology has since been used and adapted by several other researchers including Piazza and colleagues in their examinations of pica. In each study, the authors suggested a hypothesis about the specific type of sensory reinforcement and developed indirect assessment procedures to test the hypothesis.

Piazza, Hanley, and Fisher (1996b) also used stimulus preference assessments to examine the reinforcing properties of cigarette pica by breaking the cigarettes into their smallest components: paper, tobacco with nicotine, tobacco butts, herbs without nicotine, and herbal butts. Their hypothesis was that tobacco with nicotine provided some "physiological" reinforcement and would be the most important and preferred component of the cigarette. A paired-stimulus preference assessment indicated that the most highly preferred components were tobacco with nicotine (80% of trials) and herbs (17% of trials). The results of this assessment supported the hypothesis that tobacco with nicotine contributed significantly to the maintenance of pica and that placebo butts without tobacco with nicotine would probably not prove valuable in a treatment setting. A subsequent functional analysis confirmed the general automatic reinforcement function when pica only occurred in the alone condition. The findings of Piazza et al. (1996b) were later extended with four participants by Goh, Iwata, and Kahng (1999) when they conducted stimulus preference assessments to identify preferred cigarette components and competing reinforcers for cigarette pica. In addition, the authors developed effective treatments based on the results of their assessments. However, Goh et al. (1999) did not demonstrate that cigarette pica was maintained by automatic reinforcement. While their findings are clearly pertinent to the treatment of cigarette pica, we can make no conclusions about the relevance of their findings to the assessment of automatically maintained aberrant behavior.

In a second study, Piazza et al. (1998) conducted multiple analyses of the pica of three young children. In each case, an initial functional analysis indicated that pica was at least partially maintained by automatic reinforcement. The authors hypothesized that oral stimulation was important in each case and conducted single-stimulus preference assessments with stimuli that provided oral stimulation (i.e., matched stimuli) and other types of stimulation such as vestibular or tactile stimulation (i.e., unmatched stimuli). In a procedure similar to that used by Goh et al. (1995), the authors measured both aberrant behavior and engagement with each item. For each participant, matched stimuli were generally preferred over unmatched stimuli. A later treatment evaluation compared three versions of EE and indicated that EE conditions incorporating the presumed sensory function of pica (matched oral stimulation) were more effective than conditions that were not related to the hypothesized function (nonmatched).

Piazza et al. (1998) conducted a subsequent series of analyses to further examine the relevant sensory properties of pica by determining whether taste or texture was the more important aspect of oral stimulation. The authors hypothesized that firmness of oral stimuli was the important component for each of the participants. Data were collected on aberrant behavior and item engagement for four categories of food items in a single-stimulus presentation preference assessment: firm and flavored, firm and unflavored, soft and flavored, soft and unflavored. Firm stimuli were associated with lower levels of pica and soft stimuli were associated with higher levels, regardless of flavor. These findings were confirmed in a subsequent multielement evaluation of noncontingent access to food in which only hard food items were associated with lower levels of pica and flavor seemed to be an irrelevant factor. The reader should note that the Piazza et al. (1998) study contributes to the literature on stimulus preference assessment and to the literature on assessments based on NCR and sensory extinction (see below), but we have elected to discuss all aspects of the study in one location.

Piazza, Adelinis, Hanley, Goh, and Delia (2000) recently extended the above findings to other topographies of aberrant behavior maintained by automatic reinforcement. One participant exhibited dangerous behaviors such as climbing and jumping from high surfaces. A second participant played with his saliva by rubbing it on any available surface (e.g., windows, furniture) and a third participant engaged in hand mouthing. The authors applied the model described above and determined that stimulus preference assessments based on specific hypotheses (i.e., matched vs. unmatched) resulted in the development of effective interventions (i.e., noncontingent access to matched stimuli).

The four studies reviewed above primarily contribute to the research literature by introducing hypothesis-based stimulus preference assessments. The authors first examined the topographical characteristics of the aberrant behavior to generate hypotheses about the relevant sensory aspects of the behavior. They then conducted stimulus preference assessments with potentially substitutable stimuli. Finally, they used the results of these assessments to prescribe potentially function-based interventions that would result in the participant having access to an appropriate form of the same sensory stimulation produced by the aberrant behavior. However, this approach

is limited because of the reliance on the momentary preference for a stimulus to infer behavioral function. Even though the preference assessments are based on hypotheses of behavioral function, an individual's momentary preference for a stimulus is insufficient to infer an aberrant behavior's maintaining variable(s). Consequently, stimulus preference assessments based on hypotheses of behavioral maintenance share some of the problems associated with their nonhypothesis-based counterparts.

3.2. Assessments utilizing noncontingent reinforcement and sensory extinction

A series of studies has recently extended the literature by employing assessments that utilize NCR and sensory extinction procedures in the identification of automatic reinforcement sources. Instead of conducting stimulus preference assessments, researchers have either presented (NCR) or eliminated (extinction) certain sensory qualities in standardized pre-treatment assessment sessions in an attempt to identify specific sources of automatic reinforcement.

It should be noted that the term *noncontingent reinforcement* has been considered a misnomer because (a) the procedure involves response-independent rather than contingent presentation of stimuli, (b) the target behavior is decreased rather than increased, and (c) the procedure *is* contingent on the passage of time (Carr, 1996; Poling & Normand, 1999; Vollmer, 1999). However, the term NCR is the commonly accepted descriptor for the procedures discussed in this article. To avoid confusion and remain consistent with the original authors, we will use the term in reference to the time-based or continuous presentation of stimuli.

Kennedy and Souza (1995) reported one of the first studies to utilize sensory extinction and/or NCR as hypothesis-generating assessments. The authors analyzed the eye-poking behavior of a 19-year-old male diagnosed with profound disability and visual impairments. After a functional analysis indicated an automatic reinforcement function, the authors briefly evaluated a sensory extinction procedure using a reversal design. During sensory extinction, the participant wore goggles that allowed him to move his fingers to his eye without making physical contact. This condition rapidly eliminated responding, which the authors interpreted as evidence that the behavior was maintained by finger–eye contact. The authors elected to test the visual stimulation aspect of finger–eye contact by evaluating the effects of noncontingent visual stimulation and noncontingent auditory stimulation. The greatest reduction occurred in the visual-stimulation condition, supporting the authors' hypothesis that eye poking was likely maintained by a visual-stimulation product of the behavior. However, other potentially relevant sensory consequences of finger–eye contact were not investigated (e.g., tactile stimulation).

Patel, Carr, Kim, Robles, and Eastridge (2000) recently reported a series of assessments of the stereotypy (rapid lip-to-tongue movements) of one participant and the SIB (head hitting) of another participant. After a functional analysis indicated an automatic reinforcement function, the authors conducted a multielement assessment that utilized sensory extinction and/or NCR to assess behavioral function. The younger participant's conditions included noncontingent access to an audio recording

of his target behavior, noncontingent access to vibratory stimulation, and noncontingent access to moisturizer for his lips. Responding was substantially reduced during the audio-recording condition, suggesting a possible auditory function. The older participant's conditions included reduced visual stimulation, reduced forehead stimulation, and noncontingent forehead stimulation. The most substantial behavioral reduction was observed in the noncontingent forehead stimulation condition, suggesting a possible tactile-stimulation function. The authors subsequently demonstrated successful behavioral reductions under DRO schedules that incorporated stimuli from each participant's hypothesized functional class. These data must be interpreted with caution because the behavioral reductions during the sensory assessment were produced via NCR instead of extinction. Thus, the authors were unable to determine the behavioral mechanism responsible for the reduction. For example, with the younger participant, it is unclear whether auditory stimulation reduced aberrant behavior because it was initially the functional reinforcer (i.e., substitution) or because auditory stimulation was more powerful than the functional reinforcer (i.e., competition).

Wilder, Kellum, and Carr (2000) conducted a three-phase study that included a functional analysis, a hypothesis-based sensory assessment, and a treatment evaluation of head rocking. After a functional analysis indicated an automatic reinforcement function, the authors conducted a multielement assessment that included no-interaction, noncontingent auditory stimulation, noncontingent neck massage, and reduced-light conditions. The only condition that reduced head rocking was the noncontingent-massage condition, suggesting a possible tactile-stimulation or tension-reducing function. This hypothesis was supported when an EE procedure resulted in a reduction in head rocking only when a massage component was included. Although the authors presented data supportive of their hypothesis, the results should be interpreted with caution because complete reductions were not observed in the target behavior, possibly indicating a second behavioral function.

Rapp, Miltenberger, Galensky, Ellingson, and Long (1999) conducted a series of functional assessments of one woman's hair pulling and manipulation. In the first assessment, a functional analysis indicated an automatic reinforcement function. Next, the authors compared a control condition (alone) to two test conditions in a multielement design. One test condition employed NCR by including noncontingent access to hairs that were collected from her bed and after haircuts to evaluate whether hair pulling was maintained by access to hair. The second test condition employed a potential sensory extinction component by having the participant wear a tight rubber glove to evaluate whether the target behaviors were maintained by digital-tactile stimulation. The results showed that hair pulling and manipulation occurred during the alone-condition sessions, with hair manipulation also occurring during the noncontingent hair condition. These data suggested that hair pulling was likely maintained by digital-tactile stimulation produced by manipulating pulled hairs. Although Rapp et al. presented a novel assessment of an automatically reinforced "behavioral chain", the results must be interpreted with caution, as there was no subsequent treatment evaluation to validate the hypothesis-testing assessment.

Sprague, Holland, and Thomas (1997) compared the effects of noncontingent sensory reinforcement, contingent sensory reinforcement, and response interruption on the SIB and stereotypic behaviors. After demonstrating that aberrant behavior was maintained by automatic reinforcement, the authors demonstrated that the noncontingent presentation of competing sensory stimuli (i.e., tactile, auditory, combined) was more effective at response suppression than access to praise and food. Access to noncontingent tactile stimulation reduced the stereotypy and SIB of one participant, while the second participant responded to both tactile and auditory stimulation (separately and combined), suggesting multiple functions. The authors then reported a treatment evaluation that included access to the identified sensory stimulation contingent on task engagement, while the aberrant behavior resulted in response interruption in some conditions and not in others. The results of this final analysis supported the previous hypotheses about the specific source of automatic reinforcement that might have maintained the aberrant behavior.

Fisher, Lindauer, Alterson, and Thompson (1998) reported an assessment and treatment package for the stereotypic and destructive behavior of the two young males with developmental disabilities. In the first phase, the authors demonstrated that the stereotypic and destructive behaviors maintained in the absence of social consequences for each participant. The authors also provided the individuals with noncontingent access to previously destroyed materials, which resulted in a reduction in the destructive behaviors, but not stereotypy. These data indicated that the target behaviors were related in that destruction was maintained by access to materials used for stereotypy. In the second phase, the authors evaluated the noncontingent delivery of "matched" (i.e., toys that provided similar stimulation to stereotypy) and "unmatched" toys (i.e., toys that did not provide similar stimulation to stereotypy). With both individuals, the noncontingent presentation of matched stimuli resulted in low levels of destructive behavior compared to baseline conditions. Interestingly, the authors identified a "chain" of aberrant behavior that included destructive behavior followed by stereotypic manipulation of the destroyed materials. One of the limitations of this study was that the authors did not identify the specific sensory consequences (e.g., the noise produced by plastic) that were responsible for behavioral maintenance. Hence, it is unclear what behavioral mechanism was responsible for the reductions.

All six of the above studies included data supporting the authors' hypotheses of behavioral function. The hypotheses were confirmed if behavioral reductions were observed when a potential reinforcer was eliminated from (sensory extinction) or added to (NCR) an individual's environment. Reductions observed during stimulus-elimination conditions were most likely productions of extinction. These reductions provide the strongest evidence for an inference of behavioral function. Alternatively, reductions observed during NCR conditions might be a result of either reinforcer substitution or competition. Reinforcers that are effective because of substitution can be considered "function based", whereas those that are effective because of competition cannot. Currently, there is no available technology to allow us to differentiate between these effects. Hence, one of the criticisms of NCR based sensory assessments is the possibility of false-positive outcomes in which behavioral function is misidentified.

Another minor criticism of these studies is the occasional examination of only a limited number of possible sensory consequences. For example, eye poking can result in multiple sensory products (e.g., visual stimulation, finger–eye contact, arm movement). The assessment of only one possible sensory product might result in a false-negative outcome in which relevant consequences are erroneously eliminated. Consequently, an important consideration in the design of sensory assessments is the inclusion of conditions that assess as many likely sensory products as possible.

4. On the cost–benefit analysis of assessment-intensive approaches

The assessment procedures described above contribute greatly to our potential for understanding the concept of automatic reinforcement. They allow us to pinpoint specific sources of reinforcement more accurately than ever before. However, we must also consider whether these procedures represent the most cost-effective, best-practice approach for general clinical situations. The nonhypothesis-based stimulus preference assessments are relatively time- and effort-efficient procedures. However, the time and effort involved in many of the other experimental methods might be prohibitive and require a relatively high level of methodological sophistication for proper implementation.

Procedures such as differential reinforcement and EE are frequently, but not *always* effective without the use of hypothesis-based assessments. For example, Frea (1997) and Lindberg, Iwata, and Kahng (1999) demonstrated the utility of prompting and differential reinforcement of alternative behavior (DRA) in the treatment of aberrant behavior. Frea reported that repetitive eye movements and vocalizations persisted in the absence of social consequences in two adolescents with autism. During treatment, the two individuals were prompted to look at their surroundings and comment about them. Appropriate comments resulted in social praise. Thus, reinforcement for an unrelated appropriate behavior resulted in a decrease in the target behavior and a greater of level of interaction with environment. Lindberg et al. used a similar procedure (i.e., leisure training), which involved prompting and reinforcement of object manipulation to produce reductions in the SIB of two men with profound mental retardation.

Roscoe, Iwata, and Goh (1998) compared sensory extinction with NCR as treatment for the SIB of three individuals. In the sensory extinction condition, protective equipment was chosen based on response topography and was delivered to disrupt some unknown response-reinforcer relation. Thus, there was no attempt to identify the specific source of automatic reinforcement. In the NCR condition, randomly generated preferred stimuli were continuously available, similar to the procedure described by Vollmer et al. (1994). The authors demonstrated that both interventions were effective in reducing aberrant behavior and that NCR resulted in quicker and more effective response suppression than sensory extinction.

The above three studies illustrate the effectiveness of common behavioral procedures in some cases of automatically reinforced behavior. They also represent an excellent place for the clinician to begin. In general clinical practice, stimulus

preference assessments can be combined with common interventions as a first step in the treatment of automatically reinforced behavior. Clients will typically benefit in some way from enriched environments and from the reinforcement of behaviors that promote better social functioning. However, these two interventions might have no effect on aberrant behavior. If these procedures fail to produce an adequate treatment effect, the clinician can now turn to other assessment procedures to enhance treatment effectiveness. Future studies must evaluate whether the additional information gained from these assessment procedures add a substantial benefit to treatment effectiveness in exchange for the cost in clinician time and effort.

5. Summary and conclusions

We describe a series of recent studies that advance our knowledge of the role of automatic reinforcement in the maintenance of aberrant behavior. The studies fall into three domains: nonhypothesis-based stimulus preference assessments, hypothesis-based stimulus preference assessments, and hypothesis-based assessments that include NCR and sensory extinction procedures. Each of these areas of research provides a host of potential future investigations that could move the field closer to a more complete understanding of automatic reinforcement.

Vollmer (1994) illustrated some of the difficulties encountered in the treatment of automatically reinforced behavior. Each of the procedures described in this paper help to overcome those difficulties. In addition, some of these procedures have enhanced our ability to predict which common behavioral procedures are likely to be effective (e.g., Ringdahl et al., 1997). Thus, these assessment procedures show considerable promise for enhancing the clinician's intervention effectiveness. However, none of these procedures has been evaluated on a widespread basis in natural settings. We must delay evaluation of these procedures until substantially more studies have been conducted in natural settings with long-term follow-up and generalization data.

Vollmer (1994) and Kennedy (1994) each illustrated the lack of conceptual understanding surrounding the term automatic reinforcement. The studies described above have moved the field closer to that understanding. However, with the possible exception of assessments that incorporate sensory extinction, these methods still have not allowed us to identify behavioral function beyond the general category of automatic reinforcement. Our current methods do not allow us to differentiate between reinforcer substitution and competition. Refining these assessments will allow researchers to select participants based on specific behavioral function (Vollmer & Smith, 1996), which will enhance our understanding of automatic reinforcement.

In summary, we hope this review of assessment methodologies provides useful information for both researchers and clinicians. Research does not readily fall into mutually exclusive categories; but we hope this framework assists in the organization and understanding of the recent advances in the assessment of automatically reinforced aberrant behavior.

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