

FUNCTIONAL ANALYSIS AND TREATMENT OF
PROBLEM BEHAVIOR EVOKED BY NOISE

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We conducted a four-part investigation to develop methods for assessing and treating problem behavior evoked by noise. In Phase 1, 7 participants with developmental disabilities who were described as being hypersensitive to specific noises were exposed to a series of noises under controlled conditions. Results for 2 of the participants verified that noise was apparently an aversive event. In Phase 2, results of functional analyses indicated that these 2 participants' problem behaviors were maintained by escape from noise. In Phase 3, preference assessments were conducted to identify reinforcers that might be used during treatment. Finally, in Phase 4, the 2 participants' problem behaviors were successfully treated with extinction, stimulus fading, and a differential-reinforcement-of-other-behavior (DRO) contingency (only 1 participant required DRO). Treatment effects for both participants generalized to their home environments and were maintained during a follow-up assessment. Procedures and results were discussed in terms of their relevance to the systematic assessment of noise as an establishing operation (EO) and, more generally, to the identification of idiosyncratic EO influences on behavior.

DESCRIPTORS: escape behavior, establishing operations, functional analysis, noise

Since the publication of Michael's work (1982, 1993) on establishing operations (EOs), researchers have examined a number of ways in which EOs can alter the effects of contingencies, especially those that maintain problem behavior (e.g., see recent reviews by McGill, 1999, and Smith & Iwata, 1997, and the special issue of the *Journal of Applied Behavior Analysis*, 2000, Vol. 33, No. 4). Although it has been suggested that a wide range of EOs may evoke problem behavior, most research has been limited to three general classes of events: (a) deprivation from positive reinforcers such as food (Wacker et al., 1996), attention (Fischer,

Iwata, & Worsdell, 1997), or leisure activities (Marcus & Vollmer, 1996); (b) aversive task demands (Carr, Newsom, & Binkoff, 1980; Smith, Iwata, Goh, & Shore, 1995); and (c) physical conditions that may either cause discomfort or decrease tolerance to environmental stimulation (Kennedy & Meyer, 1996; O'Reilly, 1995, 1997).

One potential EO that has received little attention in research on behavior disorders but has been mentioned frequently in the nonexperimental literature (Bettison, 1996; Feldman & Griffiths, 1997) is noise. For example, it has been suggested that as many as 40% of children having the diagnosis of autism show evidence of auditory hypersensitivity (Rimland & Edelson, 1995).

Recent studies have documented the aver-

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sive properties of noise by demonstrating that an audible tone delivered contingent upon the occurrence of habit behavior can function as punishment (Ellingson *et al.*, 2000; Rapp, Miltenberger, & Long, 1998). However, few studies have directly examined the extent to which noise can serve as an EO for problem behavior, and none of these studies included treatment data. In a large-scale analysis of self-injurious behavior (SIB), Iwata *et al.* (1994) reported that 1 participant (out of 152) exhibited higher rates of SIB during a condition in which music that played during the session was briefly terminated contingent on SIB. The authors noted that even a telephone ringing during the assessment seemed to occasion this participant's SIB. However, a detailed description of the procedures used in the "music condition" was not provided. In a subsequent study, Smith *et al.* (1995) included a music condition in a functional analysis of the SIB of an adult with profound mental retardation. During this condition, loud music was played continuously but was terminated for 20 s whenever the man engaged in SIB. Results showed that the highest rates of SIB were observed during the music condition, indicating that music served as an EO for escape behavior. O'Reilly (1997) observed that a young girl's SIB occurred at its highest rates when she showed symptoms of otitis media and when a radio was played at a high volume (with and without a 10-s escape period contingent on SIB). Although other possible functions were not ruled out (e.g., escape from noise in the absence of otitis media was not examined), results suggested that noise served as an EO for SIB in the presence of otitis media. Finally, O'Reilly, Lacey, and Lancioni (2000) observed that another young girl's problem behavior occurred at high rates only in the presence of both demands and noise (prerecorded classroom activity played at an unknown volume).

Results of these studies indicate that various types of noise may serve as EOs for problem behavior in persons with developmental disabilities. However, additional research is needed to identify both qualitative and quantitative characteristics of noise that determine its influence as an EO on an individual basis, as well as to develop effective treatment strategies. The current study was designed to extend previous research in this area by illustrating a systematic method for evaluating the potentially aversive properties of noise and for evaluating treatment procedures designed to reduce problem behavior evoked by noise.

METHOD

Participants

Seven adults, all living in a residential program for persons with developmental disabilities, were selected for participation based on staff referral, observational data, or results from functional analysis probes suggesting that exposure to noise constituted an aversive event for each person. Two individuals participated in all phases of the study. Debbie was a 43-year-old woman who had been diagnosed with profound mental retardation and autism and who communicated using gestures and by physically guiding staff toward desired objects. Staff reports and informal observation indicated that Debbie typically responded to the sound of fire alarms and telephones by engaging in SIB (slapping or biting herself), property destruction (throwing objects), aggression (pinching, scratching, hitting, or kicking others), and stomping her feet. Sarah was 41-year-old woman who had been diagnosed with severe mental retardation and who communicated using short phrases. She had a severe loss of hearing in her right ear, presumably from years of SIB, and profound visual impairment. Staff reports and informal observation suggested that Sarah en-

gaged in various problem behaviors (e.g., yelling, cursing, SIB, aggression, and property destruction) in response to socially provocative statements (insults) uttered at above the level of normal conversation by peers in her home. The remaining 5 individuals participated only in Phase 1. They ranged in age from 25 to 44 years and had been diagnosed with severe to profound mental retardation. Joe's and Judy's problem behaviors (SIB and aggression or property destruction, respectively) reportedly occurred when they heard others engage in loud vocalizations (e.g., screaming, arguing, or crying). Melissa's and Harold's problem behaviors (aggression and SIB, respectively) reportedly occurred when others nearby exhibited loud tantrums. Finally, Paula's caregivers reported that she engaged in SIB when the housekeeper operated the floor waxing machine nearby.

Setting and Apparatus

Assessment and treatment sessions were conducted in a room (5 m by 4 m) equipped with a one-way observation window. An audio receiver, cassette player, and sound amplifier were located in an adjoining observation booth. Five speakers (connected to the audio receiver) were mounted in the ceiling of the assessment room (one in each corner and one in the center of the room) to ensure that sound levels remained relatively constant in the event that the participant moved about the room during sessions. Noises were prerecorded and were played during sessions on standard audiocassette tapes. A Radio Shack sound level meter was used to measure noise level (in decibels), and an electronic timer was used to measure session time and the occurrence of problem behavior.

Generalization and follow-up probes were conducted in the living areas of the participants' home. These areas were furnished

with couches, tables, chairs, various fixtures, televisions, and radios.

PHASE 1:

ASSESSMENT OF NOISE AVOIDANCE

Prior to conducting a functional analysis, a preliminary assessment was undertaken to identify the most relevant noises for inclusion in the remaining phases of the study. This phase also served to screen out participants who did not exhibit problem behavior in response to the noises tested.

Selection of Noises and Decibel Levels

Each participant was exposed to noises that were either identical or similar to those suggested by staff as potential EOs for problem behavior. For example, a tape of a group of people screaming was included as one noise in Joe's assessment. In addition, tapes of white noise and a man talking in normal conversation tones were included as controls for any type of noise and a frequently encountered noise, respectively. Table 1 lists the noises to which each participant was exposed.

The initial decibel levels were based on established normative parameters (Northern & Downs, 1978). Given that normal conversation occurs at about 40 to 60 dB, all noises were initially tested at 65 dB. This decision was based on the fact that all of the participants lived in congregate settings in which the general noise level was likely to be somewhat higher than that of normal conversation. Also, the purpose of the current study was to examine sensitivity to noise, which we defined as sounds having a somewhat higher volume than that encountered routinely. All noises were initially tested at the same volume so that any observed differences in behavior could be attributed to the type of noise rather than to its intensity. The maximum level was usually 75 dB. However, measurements taken in the natural

Table 1
Stimuli Presented in Phase 1 (Noise Assessment)

	Debbie	Sarah	Joe	Judy	Melissa	Harold	Paula
Man screaming	X		X	X	X	X	
Group screaming			X	X	X	X	
Man talking	X	X	X	X	X	X	X
Phone ringing	X		X	X		X	X
Alarm clock	X				X		X
Fire alarm	X						
White noise	X	X	X	X	X	X	X
Floor wax machine							X
Provocation by A		X					
Provocation by B		X					
Friendly voice by A		X					
Loud voice by D		X					
Loud voice by E		X					
Loud voice by F			X	X			

environment from a distance of 2 m from some noises that were reported to evoke problem behavior in 3 participants exceeded 75 dB (e.g., the fire alarm registered 100 dB). As a result, the natural decibel levels for these particular noises were used during the 3 participants' assessments, following consultation and approval by an audiologist.

Procedure

Participants' responses to the various noises were assessed in a multielement design. Noises were presented in random order a minimum of three times each during 5-min sessions. Five sessions (one round) were typically conducted each day. Each session consisted of exposure to one noise, and sessions were separated by 2 to 5 min to prevent carryover and to allow time for sound recalibration prior to the next session. If a moderate to high level of problem behavior was observed in the presence of a particular noise (relative to other noises), additional sessions were conducted at that volume. If little or no problem behavior was observed at the initial volume, the level was adjusted upward by 5 dB during a subsequent session.

During each session, the participant sat alone at a table or next to a therapist who

refrained from social interaction (the presence of a therapist was necessary for participants whose problem behaviors included aggression). One or more leisure items were placed on the table to allow opportunities to score property destruction. When a session began, the taped noise was played continuously but was stopped for 30 s contingent upon the occurrence of a participant's targeted problem behavior.

Response Measurement and Reliability

Problem behaviors were individually defined (available from the first author upon request) and included aggression (hitting, kicking, scratching, biting, grabbing others), SIB (head hitting, face slapping, hand biting), property destruction (throwing or kicking objects), and tantrums (crying, yelling, cursing). During each session, observers recorded the occurrence of problem behavior using a 10-s partial-interval scoring method. Interobserver agreement was assessed by having two observers simultaneously but independently record data during 43% of the sessions across participants. Agreement scores were calculated on an interval-by-interval basis by dividing the number of intervals with agreements by the number of

intervals with agreements and disagreements and multiplying by 100%; these values averaged 97% (range, 83% to 100%).

An observer also recorded the decibel levels of the prerecorded tapes prior to each session to assess consistency in the delivery of sound. Two observers independently recorded these measures during 46% of the sessions. An agreement was scored if both observers' measures were within ± 2 dB of each other, and all of these assessments yielded 100% agreement.

Results

Joe, Judy, Melissa, and Harold never exhibited problem behavior in the presence of any of the tested noises at 65, 70, and 75 dB. In fact, none of these participants displayed any behavior that might be considered indicative of discomfort (e.g., grimacing, holding their ears, or attempting to leave the room). Paula exhibited SIB in the presence of two different noises (man talking, problem behavior observed during one of four sessions; and white noise, problem behavior observed during one of three sessions); however, these were the control noises. By contrast, she never exhibited SIB to the sound of the floor waxing machine (which was reported by staff to evoke her problem behavior). Based on these negative findings, we concluded that staff reports apparently identified an incidental correlation between the presence of noise and the occurrence of problem behavior, but the noises tested were not EOs for problem behavior exhibited by any of these participants. Joe, Judy, Melissa, Harold, and Paula were excluded from the remainder of the study. Subsequent assessments were conducted to identify the functional characteristics of these participants' problem behaviors (which were unrelated to noise) but are not reported here.

Debbie's highest percentages of problem behavior were observed in the presence of

the telephone ringing. Problem behavior also occurred under two other conditions (alarm clock and white noise). Thus, one noise (telephone) corresponded to that reported by staff to evoke Debbie's problem behavior, but the other (the fire alarm, which evoked no problem behavior in the assessment) did not. In addition, Debbie's primary problem behaviors (SIB, aggression, property destruction) all decreased to zero across repeated exposure to these noises at higher decibel levels (these data are not shown) and were replaced by other behaviors (moaning, whining, stomping feet). Thus, it appeared that across the 31 sessions of the assessment, Debbie's original target behaviors showed evidence of extinction. To determine whether her newly emergent behaviors would persist in the presence of noise, we revised her response definitions and repeated the assessment. Figure 1 shows the results of Debbie's second assessment. Across repeated presentations of five sounds, each at a higher decibel level, Debbie's problem behaviors persisted only in the presence of the telephone ringing, thus replicating the general finding from her first assessment.

Sarah exhibited no problem behavior in the presence of any noises played at 65 dB (see Figure 1). When the noise level was increased to 70 dB, Sarah exhibited problem behaviors in the presence of all noises except the Peer B tape. Two additional sets of sessions were conducted at 70 dB, during which Sarah's problem behaviors decreased to zero under all conditions but one (the Peer A tape). These results suggested that, as reported, much of Sarah's problem behavior appeared to be occasioned by provocative statements made by a peer.

PHASE 2: FUNCTIONAL ANALYSIS

Results obtained in Phase 1 suggested that specific noises may have functioned as EOs for Debbie's and Sarah's problem behaviors.

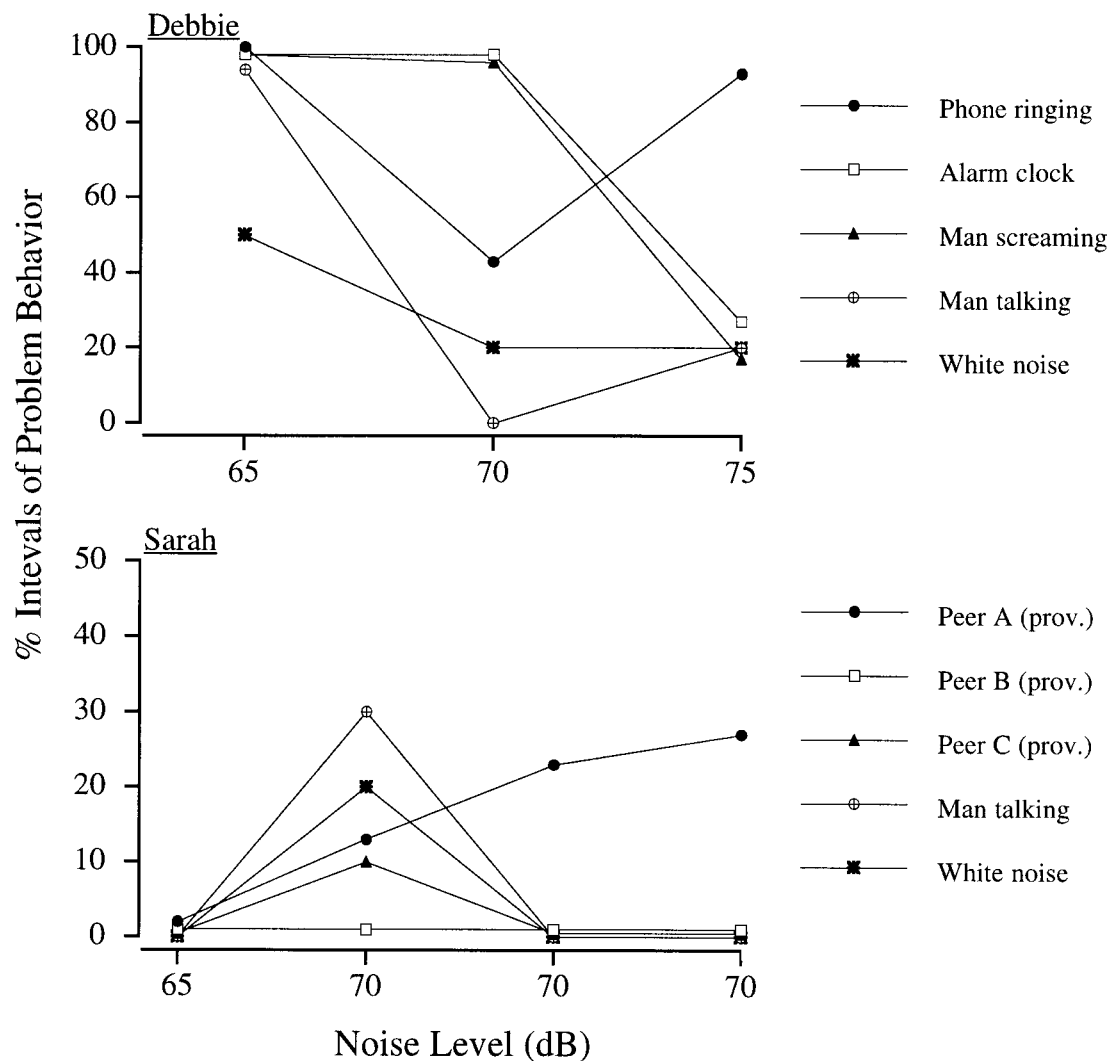


Figure 1. Results of Debbie's and Sarah's noise assessments.

However, because all of the assessment conditions involved exposure to noise of one sort or another, it was unclear whether similar rates of problem behavior would be observed in the absence of noise. Thus, the purpose of Phase 2 was to examine levels of problem behavior under more typical test (noise) and control (no noise) conditions.

Procedure

Debbie and Sarah were exposed to three conditions arranged in a multielement design based on procedures described by Iwata,

Dorsey, Slifer, Bauman, and Richman (1982/1994). Each session lasted for 10 min, and conditions were sequenced in a semirandom manner. Leisure materials were present in all conditions. The noise condition was based directly on results obtained in Phase 1. During Debbie's sessions, a tape was played of a telephone ringing at 75 dB; during Sarah's sessions, a tape was played of Peer A making provocative statements (e.g., "shut up") at 70 dB. Contingent on the occurrence of problem behavior, the tape was stopped for 30 s. In the play condition, a

therapist delivered nearly continuous social interaction (e.g., praise statements, general social conversation) in a normal voice. Occurrences of problem behavior were ignored. In the no-interaction condition, a therapist was present (to serve as a target for aggression if it occurred) but did not interact with the participant at any time during the session. No noise was played during the play and no-interaction conditions.

Response Measurement and Reliability

Occurrences of problem behavior and decibel levels were recorded as described previously, and the same methods were used for calculating interobserver agreement. Reliability for data on problem behavior was assessed during 89% of the sessions and averaged 98.5% agreement (range, 90% to 100%). Reliability for sound level was assessed during 15% of the sessions and was always 100%.

Results

Results of the functional analysis are shown in Figure 2. Both participants engaged in little or no problem behavior during the play and no-interaction conditions but consistently engaged in either high (Debbie) or moderate (Sarah) levels of problem behavior when noise was present as an antecedent event and was terminated as a consequence. These data verified the results from Phase 1 and clearly indicated that Debbie's and Sarah's problem behaviors were maintained by escape from noise (negative reinforcement).

PHASE 3:
PREFERENCE ASSESSMENT

Procedure

Preference assessments were conducted to identify potential reinforcers that might be used in conjunction with treatment programs. Seven (Debbie) or six (Sarah) edible items were selected based on interviews with

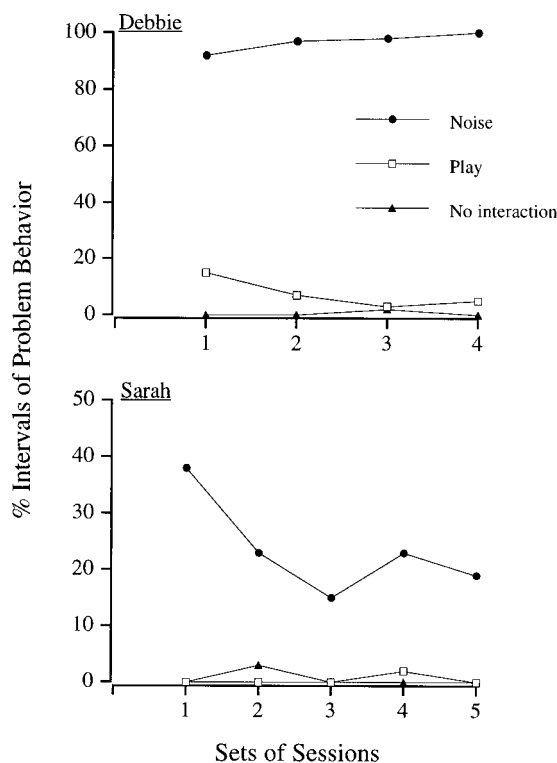


Figure 2. Results of Debbie's and Sarah's functional analyses.

staff or existing treatment data suggesting that the items seemed to function as reinforcers. (Preference for leisure items was also assessed for both participants; details are not reported here because leisure items were never used during treatment.) One or two sessions were conducted daily with at least a 3-hr interval between sessions. Prior to each session, participants were allowed to sample (consume) each item.

Debbie's assessment entailed a multiple-stimulus presentation format (DeLeon & Iwata, 1996). During each session, a therapist sat across from Debbie at a table and arranged seven food items in a row in front of her. The therapist then instructed Debbie to "pick one" and allowed Debbie to consume the item selected. Before initiating the next trial, the therapist rearranged the remaining items by moving the item at the far left to the far right. Trials continued in this

manner until all items were consumed or until a 30-s period occurred during which Debbie made no selection, whichever came first.

A modified paired-stimulus procedure (Paclawskyj & Vollmer, 1995) was used to accommodate Sarah's visual impairment. During each trial, the therapist presented two food items to Sarah and guided her to touch each item. The therapist then guided Sarah's hands to her lap, instructed her to "pick one," and allowed her to consume the item selected. The therapist removed the unselected item and then initiated the next trial with a different pair of items. If Sarah made no attempt to select an item within 5 s, the guidance procedure was repeated once. Trials continued in this manner until all pairs of items were presented or until a 30-s period occurred during which Sarah made no selection, whichever came first.

Response Measurement and Reliability

An observer recorded the item selected on each trial. Interobserver agreement was assessed by having two observers simultaneously but independently record data during 80% of the trials. Reliability was calculated by dividing the number of agreements on item selection by the number of agreements plus disagreements and multiplying by 100% and yielded an agreement score of 96%.

Results

Debbie showed a strong preference for Milky Way® (see Figure 3), selecting it first during every session. Sarah also showed a noticeable preference for one item (cheese puffs), although her overall selections were somewhat more evenly distributed.

PHASE 4: TREATMENT EVALUATION

Several types of interventions have been used as treatment for escape behavior, in-

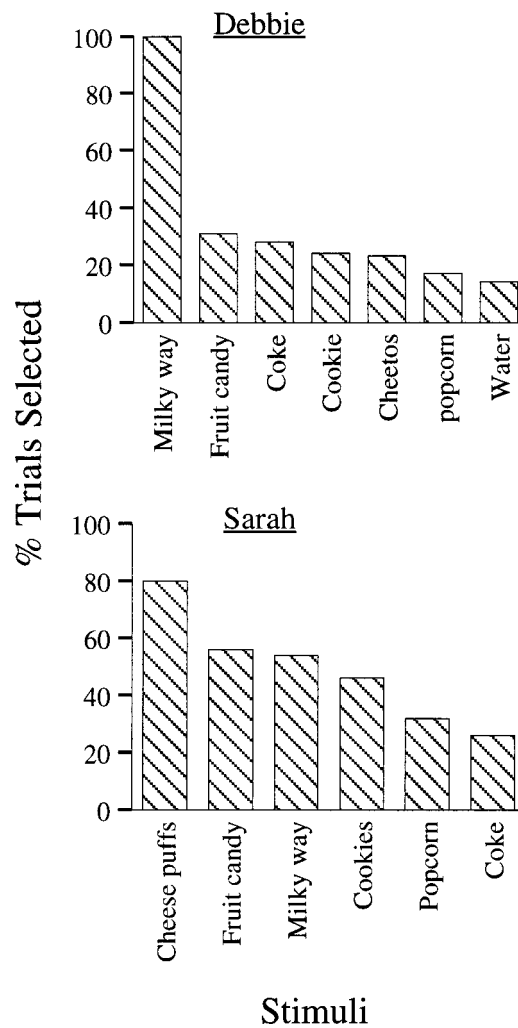


Figure 3. Results of Debbie's and Sarah's preference assessments.

cluding extinction (Iwata, Pace, Kalsher, Cowdery, & Cataldo, 1990), noncontingent reinforcement (Vollmer, Marcus, & Ringdahl, 1995), and differential reinforcement of alternative behavior (Lalli, Casey, & Kates, 1995). Given the ubiquitous and unpredictable nature of noise, and the fact that it may often be difficult to terminate many ongoing noises (on either a contingent or noncontingent basis), our approach to treatment was based on increasing tolerance to noise rather than on establishing appropriate escape behavior. Thus, the basic procedure

used during treatment was extinction. To decrease the likelihood of problem behavior from the outset of treatment, we first decreased the volume of noise during sessions and then gradually increased it using stimulus fading procedures (Pace, Iwata, Cowdery, Andree, & McIntyre, 1993).

Procedure

Baseline. This condition was similar to the noise condition of the functional analysis (the tape of the telephone ringing was played for Debbie; provocative Peer A was played for Sarah). However, there were several procedural differences. First, the noises were played at the terminal goal volume (85 dB for Debbie, 70 dB for Sarah; these were the noise levels recorded in the natural environment). Second, extinction was in effect throughout baseline and all subsequent conditions (i.e., problem behavior no longer terminated noise). Third, sessions lasted for only 1 min to minimize exposure to noise and to reduce the likelihood that extinction of problem behavior might occur prior to treatment.

Stimulus fading. Sessions were conducted as in baseline with one exception. At the beginning of the treatment condition, noise volume was decreased to a level at which no problem behavior was observed; this corresponded to slightly less than 50 dB for Debbie (50 dB was the lowest precise value on the sound meter) and 51 dB for Sarah. A series of probes were conducted to determine these values individually. Subsequently, noise volume was increased by 2 dB following three consecutive sessions during which no problem behavior was observed. If a decrease in problem behavior was not observed at a given volume, the volume was decreased to its previous level, and the criterion for increasing the volume was doubled (i.e., volume was increased by 2 dB following six consecutive sessions without problem behavior).

DRO. Because we were unable to reach the terminal volume during Sarah's treatment using just the stimulus fading procedure, we added a DRO contingency. During this condition, a therapist delivered a preferred edible item (half a cheese puff) to Sarah following each 6-s interval in which problem behavior was not observed. If problem behavior occurred, the food was withheld and the DRO interval was reset. The DRO interval was increased by 2 s following three consecutive sessions during which no problem behavior was observed, until reinforcement was delivered only at the end of the session.

Generalization probes. Assessments were conducted in each participant's home to determine the extent to which changes in behavior observed during treatment sessions would occur under more naturalistic conditions. One probe (Generalization A) involved a small degree of change from the training context; the other (Generalization B) involved a larger degree of change. During these probes, noise was presented at its terminal volume, and the conditions in effect were the same as those at the end of treatment (extinction for Debbie; extinction plus DRO for Sarah). Debbie's Generalization A probe was conducted in a day room with no other peers present. During the session, Debbie was seated in a couch approximately 2 m away from a telephone. The same therapist who conducted Debbie's functional analysis sat near her throughout the session. From another location, an experimenter used a telephone to dial the number of the telephone closest to Debbie and allowed the phone to ring uninterrupted for 1 min. In all other respects, these sessions were conducted as described previously. Debbie's Generalization B probe was similar, except that (a) it was conducted in a living room with a number of her peers and staff present (approximately 10 people), and (b) the therapist did not sit next to Debbie. Sa-

rah's Generalization A probe was conducted in the living room with peers and staff present (approximately 10 people). During the session, the tape used during treatment (Peer A) was played. In all other respects, Sarah's Generalization A probe was identical to her DRO condition. Sarah's Generalization B probe was similar, except that a tape of a novel person was played. Tape recordings were used because arranging actual confrontations between Sarah and her peers was not feasible.

Follow-up. Maintenance of treatment effects was assessed 2 weeks after the generalization probes were conducted. Procedures were identical to those used for each participant's Generalization B probe.

Experimental Design

A multiple baseline design across subjects was used to evaluate the effects of stimulus fading. The DRO component of Sarah's treatment was evaluated in a reversal design.

Response Measurement and Reliability

We used interval recording to measure problem behavior in Phases 1 and 2 because we were unsure whether response frequency or duration would provide a more stable measure. Examination of the data collected during those sessions indicated that duration better reflected changes in problem behavior. Therefore, in Phase 4, an observer recorded the total duration of problem behavior on a stopwatch during each session. Noise volume also was recorded as described previously. Interobserver agreement for problem behavior was assessed during 31% of Debbie's sessions and 63% of Sarah's sessions, and was calculated by dividing the shorter of the two observers' times by the longer and multiplying by 100%. Mean agreement scores were 100% and 99% for Debbie and Sarah, respectively. Interobserver agreement for noise volume was assessed during 19% of Debbie's sessions and 24% of Sarah's ses-

sions, and was calculated as described previously. Agreement scores for Debbie and Sarah were 100% and 97%, respectively.

Results

Debbie's problem behavior occurred during a mean duration of 53 s in baseline and decreased immediately to zero when the noise volume was lowered from 85 dB to 50 dB (see Figure 4). As the noise volume was gradually increased, her problem behavior remained low until the volume reached 79 dB (Session 55). At that point, her problem behavior increased and necessitated a decrease in volume to 77 dB. Debbie's problem behavior increased again (Session 63) but subsequently decreased and remained low until the volume reached the terminal level of 85 dB (Session 91). Volume was decreased a second time (to 83 dB, Session 93) but reached the terminal goal again, and Debbie's problem behavior remained at zero. Debbie engaged in no problem behavior during both generalization probes (A, Session 109; B, Session 111) and during her 2-week follow-up (Session 113).

Sarah's results were initially very similar to those obtained for Debbie. Sarah's problem behavior averaged 16 s during baseline and decreased to zero when the noise volume was lowered from 70 dB to 51 dB. However, as noise volume increased, Sarah's problem behavior emerged sooner than did Debbie's. Two reductions in noise volume occurred before it reached 65 dB (Sessions 30 and 42), and problem behavior reemerged whenever the volume was subsequently increased. Thus, it appeared that the fading procedure was having limited success. As a result, the DRO contingency was implemented beginning on Session 64 and resulted in an immediate decrease in Sarah's problem behavior to zero. Two reversals were then conducted, during which the DRO procedure was removed, and were associated with increases in problem behavior. Sarah's problem behavior

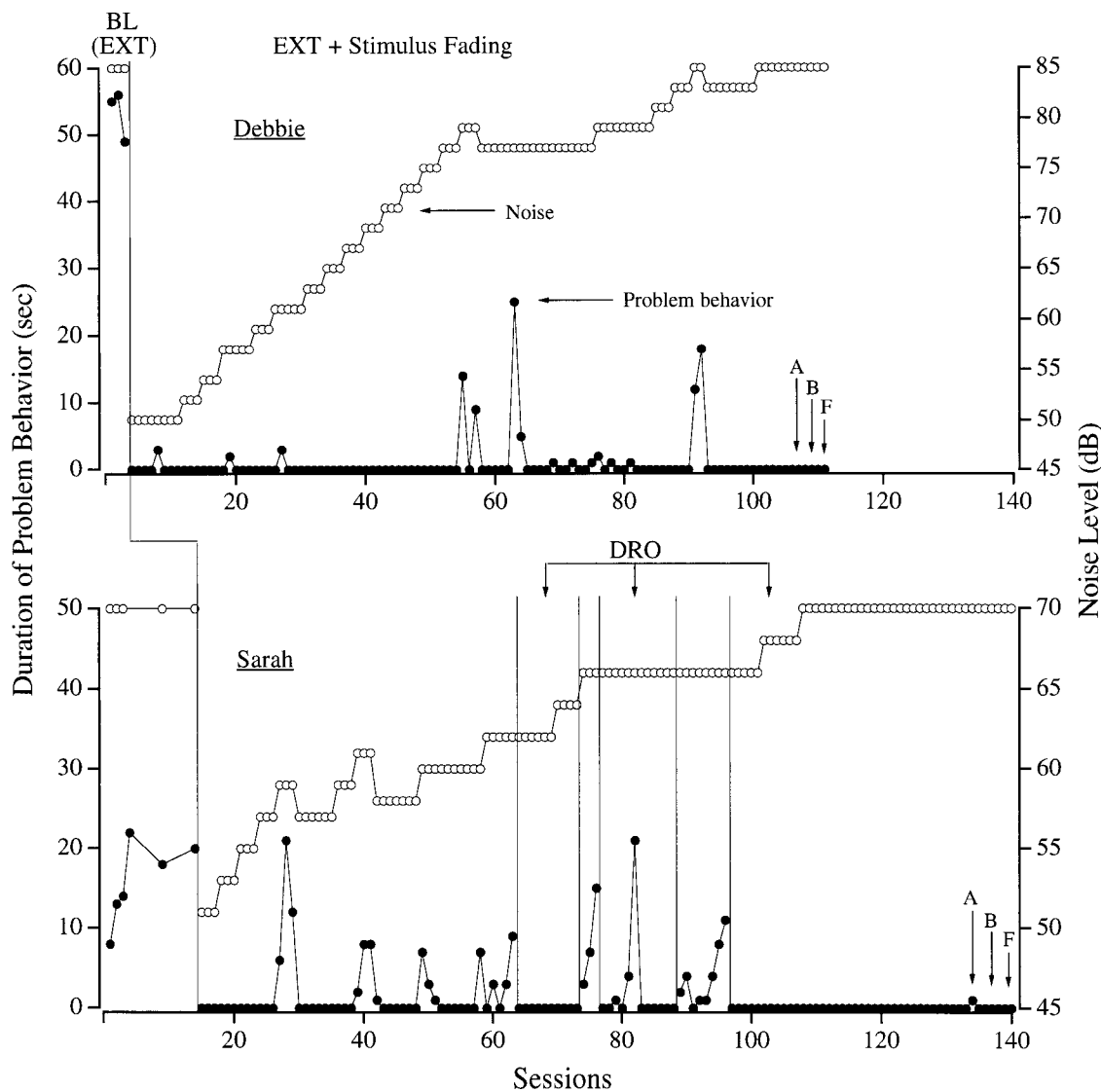


Figure 4. Results of Debbie's and Sarah's treatment evaluation. Sessions marked A and B near the end of treatment indicate two generalization probes in the natural environment; F indicates a follow-up probe.

also increased briefly during the second DRO condition (Session 82) but subsequently decreased. Her problem behavior remained at or near zero during the final condition, while the DRO schedule was gradually lengthened. Noise volume reached the terminal value of 70 dB on Session 108, and the DRO schedule reached its terminal value (60 s, the entire session) on Session 132. Sarah engaged in problem behavior only briefly during her Generalization A probe but en-

gaged in no problem behavior during her Generalization B probe and at follow-up.

DISCUSSION

A number of reports, as well as some preliminary data from functional analyses, have suggested that noise may evoke problem behavior in individuals with developmental disabilities. This is not surprising, given the potentially aversive characteristics of noise.

However, individual hypersensitivity to noise is usually determined from anecdotal sources. All of the participants in Phase 1 of this study were selected based on repeated reports from staff that problem behaviors seemed to be “caused” by particular noises. However, when exposed to a series of noises in a controlled manner, only 2 of the 7 participants showed positive reactions (i.e., problem behavior). Further analysis (Phase 2) revealed that these 2 participants (Debbie and Sarah) were indeed sensitive to noise as an EO and that their problem behaviors were maintained by negative reinforcement (escape). These data, combined with the results from preference assessments (Phase 3, relevant to Sarah only) allowed us to develop systematic interventions that increased Debbie’s and Sarah’s tolerance to noise. Moreover, behavior changes obtained under controlled treatment conditions were observed to generalize to participants’ home environments and to be maintained over time, although these data are limited because of the absence of in-home baseline measures.

The assessment conducted in Phase 1 required both a high degree of control over ambient noise and a means of exposing individuals to noise in a relatively precise manner. Given that this arrangement may be unfeasible in many service settings, its general utility may be questioned. However, the assessment allowed us to observe participants’ responses to a range of both qualitative and quantitative characteristics of noise (see Iwata, Smith, & Michael, 2000, for a discussion of the utility of this strategy). In previous studies in which there was an attempt to assess sensitivity to noise (Iwata et al., 1994; O’Reilly, 1997; Smith et al., 1995), only one noise was used and it was delivered at unknown and potentially variable levels. The procedures used in Phase 1 decreased the likelihood of obtaining negative results because of inadequate sampling. Results of this assessment indicated that only 2 of the 7

participants showed reactions that might be considered hypersensitivity to noise. In the absence of the assessment conducted in Phase 1, it is possible that 5 of the participants (the nonresponders) would have been exposed to treatment programs, based on erroneous anecdotal data, that would have been ineffective and perhaps would have consumed more time and resources than those required by our assessment. Thus, in spite of its complexity, the noise assessment served as an effective and ultimately an efficient method for screening clients referred for “hypersensitivity to noise.”

The procedures used in Phase 1 also illustrate an extension of functional analysis methodology to the identification of highly idiosyncratic environmental influences on behavior. It is unlikely that we would have identified (or eliminated) noise as a relevant environmental event had clients been exposed only to functional analyses that assessed sensitivity only to typical sources of reinforcement for problem behavior (i.e., access to attention, escape from demands, etc.). In fact, Phase 1, as implemented in the present study, amounted to a more refined assessment for several participants whose initial functional analyses showed mixed results (these data were not presented because they were clinical in nature and lacked adequate reliability assessment). Thus, in practice, the preferred (i.e., more efficient) strategy would consist of first conducting a typical functional analysis and then proceeding to more refined assessments as needed.

Given that the results obtained in Phases 1 (noise assessment) and 2 (functional analysis) were similar, it is unclear whether both phases were necessary. However, although the results obtained in Phase 2 verified observations from Phase 1, they would not necessarily have been obtained had we included either any noise (selected randomly) or even the noise identified as problematic by staff who worked with the participants

daily. That is, although provocative comments did indeed evoke Sarah's problem behavior (as reported by staff), the fire alarm had no effect on Debbie's behavior. Thus, Phase 1 was helpful in identifying specific noises to be included in Phase 2. Similarly, Phase 2 was helpful, at least from the standpoint of research methodology, because its results (unlike those obtained in Phase 1) showed that Debbie's and Sarah's problem behavior did not occur in the absence of noise.

The intervention phase of the present study was significant because it represents the first attempt (of which we are aware) to integrate assessment information with the treatment of problem behavior evoked by noise. The primary treatment, extinction combined with stimulus fading, was based on procedures described in a number of previous reports (e.g., Pace, Ivancic, & Jefferson, 1994; Pace et al., 1993; Zarcone, Iwata, Smith, Mazaleski, & Lerman, 1994; Zarcone et al., 1993); however, the stimuli used during treatment were unusual. During the course of Sarah's treatment, we observed a problem also noted by Zarcone et al. (1994), in that the stimulus fading procedure was unsuccessful in reaching the end-of-treatment criterion. Zarcone et al. (1994) resolved the problem by implementing extinction. Given that extinction was in effect at the outset of intervention in our study, we supplemented Sarah's treatment by explicitly reinforcing tolerance to noise (DRO). As indicated through repeated reversals, the DRO procedure facilitated treatment effects. Thus, stimulus fading, with DRO for Sarah, resulted in elimination of problem behavior at noise levels that both participants previously found intolerable. Finally, probes conducted at the end of treatment showed that problem behavior did not occur when participants were observed under noisy conditions in their homes.

Although the current study provides an

initial framework for assessing and treating problem behavior negatively reinforced by the termination of noise, additional issues remain to be addressed in future work. One of these is the role of extinction in the assessment of EOs that have aversive properties. The gradual reduction of Debbie's problem behavior to zero during her first noise assessment (data not shown) suggested that extinction (diminished responding due to the termination of a contingency) may have occurred. On a molecular level, Debbie always received 30 s of escape from noise contingent upon problem behavior (i.e., an escape contingency was always in effect). On a more molar level, however, escape from noise was transient because noise always reappeared at the end of the escape interval. Thus, it is possible that extinction occurred if the brief escape intervals were ineffective as negative reinforcement. A similar type of situation may arise in more typical functional analyses when problem behavior produces very brief escape from ongoing instructional demands. Although, to our knowledge, extinction of escape during assessment has not been reported in previous studies, it could occur under certain conditions even in the presence of a contingency.

A second issue that should be explored in future research is the extent to which noisy conditions actually evoke problem behavior. In spite of previous suggestions that many individuals with developmental disabilities show hypersensitivity to noise, our findings were generally negative. Given the resources necessary to develop assessment procedures used in the present study, we attempted to identify every individual (out of over 280 living at the center where the study was conducted) whose problem behaviors were reported to be associated with noise. Only 7 individuals were identified, and results of our assessment showed that only 2 of the 7 displayed any problem behavior under a range of noisy conditions. These results sug-

gest that the extent to which noise evokes problem behavior may be overestimated. Thus, replications of the methodology used in the present study may help to establish a more empirical basis for determining the prevalence of noise-related problem behavior.

Alternative approaches to intervention should also be explored. As noted previously, our rationale for selecting "tolerance" as the target behavior was based on the fact that the noises (telephone ringing, provocative statements made by peers) that served as EOs for problem behavior in our participants were common, unpredictable, and difficult to eliminate completely. Even so, alternative forms of treatment (e.g., teaching one to walk away from sources of loud noise or from insulting statements made by others) could have been considered. In addition, when circumstances allow the termination of noise (e.g., when a radio or television is playing loudly), the strengthening of a communicative response (Carr & Durand, 1985) that results in therapist-mediated escape seems to be an attractive alternative to the intervention used in the present study.

Finally, one implication of the O'Reilly *et al.* (2000) data is that certain antecedent events may have little effect on behavior when presented separately yet may function as an EO when combined. Noise may represent such an event. For example, it is possible that Debbie's problem behavior would have occurred in the presence of the fire alarm had her assessment been conducted in her home, where a fire alarm going off would have been paired with other potentially aversive events (e.g., other clients exhibiting agitated behavior, staff delivering loud instructions to vacate the building, etc.). The extent to which interactions among EOs influence problem behavior is currently unknown and should be pursued in future investigations.

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STUDY QUESTIONS

1. In what ways did the authors attempt to extend research on the role of noise as an establishing operation (EO) for problem behavior?
2. List the key methodological features of the noise assessment (Phase 1).
3. Summarize the results of the noise assessment. Why was Debbie's assessment modified?
4. Why was a functional analysis conducted (Phase 2), and what were the results of the analysis?
5. How did the measurement procedure differ during assessment and treatment, and what was the authors' rationale for making this change?

6. Describe the treatment procedures that were implemented in Phase 4, and summarize the results that were obtained.
7. What was the clinical value of the noise assessment, given that the procedures were relatively complicated and expensive?
8. The authors raised the possibility that extinction may have occurred during the assessment. How might one prevent such an outcome? What other factors might account for reductions in problem behavior during assessment?

Study questions prepared by John Adelinis and Pamela Neidert, The University of Florida