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A Systematic Desensitization Paradigm to Treat Hypersensitivity to Auditory Stimuli in Children with Autism in Family Contexts

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Many children with autism display reactions to auditory stimuli that seem as if the stimuli were painful or otherwise extremely aversive. This article describes, within the contexts of three experimental designs, how procedures of systematic desensitization can be used to treat hypersensitivity to auditory stimuli in three young children with autism. Stimuli included the sounds from a vacuum cleaner, blender, hand-mixer, toilet flushing, and specific animal sounds from musical toys. A changing criterion design was used and data were collected on (a) the number of hierarchical steps completed as comfortable with the stimulus per week and (b) the mean level of anxiety per probe. A clinical replication was implemented using a replication of the desensitization procedures for three children. In addition, a systematic replication across three different stimuli is presented for one child in a multiple baseline. The data show that the children's responses could be modified to the point where they were comfortable with these noises. Furthermore, this level of comfort was maintained at follow-up. The discussion suggests that the extreme reactions to auditory stimuli many children with autism exhibit may be decreased with procedures that have been shown to be effective with reducing phobias, and the possibility that the reactions may be symptomatic of a phobia rather than actual pain.

DESCRIPTORS: desensitization, autism, hypersensitivity, auditory stimuli, families

Many children with autism are described in the literature as having auditory abnormalities, including reports of hypersensitive hearing (Grandin & Scariano, 1986; Hayes & Gordon, 1977; Ney, 1979; Rimland, 1964; Rimland & Edelson, 1995). Since 1964, the Autism Research Institute has collected data from over 17,000 families of children with autism. Data reveal that approximately 40% of parents of children with autism reported that their child exhibited some symptoms of sound sensitivity (Rimland & Edelson, 1995). Among other hearing irregularities, children with autism have been reported to frequently display an intense aversion to auditory stimuli, which has led to the speculation that they may even experience hyperacusis, a condition in which exposure to particular sounds frequently causes pain. The reaction can be so severe that an individual's ability to function is impaired and behaviors that are disruptive, aggressive, self-injurious, or otherwise inappropriate are often displayed (Berkell, Malgeri, & Streit, 1996; Brown, 1999). Exacerbating the problem is that many children with autism are reported as being most sensitive to common everyday environmental sounds (Vicker, 1993).

Unfortunately, many interventions designed to address sensory impairments in children with autism have not been well validated (Dawson & Watling, 2000; Goldstein, 2000). The literature has further indicated that it has been difficult to demonstrate objective and reliable changes in auditory sensitivity (Gravel, 1994; Rimland & Edelson, 1995; Tharpe, 1999). Thus, well-controlled, reliable studies are needed to develop effective interventions to address auditory sensitivity in children with autism (Dawson & Watling, 2000; Goldstein, 2000).

The literature has also suggested that many children with autism display phobias (Howlin et al., 1973; Jackson & King, 1982; Love, Matson, & West, 1990; Luiselli, 1978), many of which may be related to the difficulties

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they have with auditory stimuli (Hemsley, 1978). In other words, the child's extreme aversion to these stimuli may relate to an irrational fear of the stimulus rather than to pain associated with the stimulus. Systematic desensitization is a procedure typically used to treat phobias and is a common counterconditioning procedure used with children (Center, 1989). Some researchers have demonstrated that systematic desensitization can be used to reduce fears for children with autism during common experiences, such as a dental examination (Luscre & Center, 1996).

The purpose of this study was to assess the effects of a systematic desensitization intervention program on the apparent hypersensitivity of children with autism to common environmental auditory stimuli. Specifically, this research was designed to evaluate whether these children's intolerant reaction to common everyday sounds (vacuum cleaner, blender, hand-mixer, toilet flushing, toys) could be modified using procedures of desensitization to the point where the child would seem comfortable with these stimuli.

Method

Participants

Three children, two boys and a girl, diagnosed with autism were selected to participate in this study based on their apparently severe hypersensitivity to auditory stimuli. All children were diagnosed with autism by their pediatrician and/or a California state agency specializing in developmental disabilities according to criteria listed in the *Diagnostic and Statistical Manual of Mental Disorders—Fourth Edition* (American Psychiatric Association, 1994). The children were subsequently referred to the University of California Santa Barbara Autism Research and Training Center for intervention. All demonstrated qualitative impairments in communication and social development, and all demonstrated a restricted repertoire of interests.

Child 1, Lori, an Hispanic-American girl, was 3 years and 7 months of age at the start of the study. Recent standardized testing showed the following. On the Vineland Adaptive Behavior Scales, Lori scored an age equivalent of 1 year 4 months on the Communication Domain, 1 year 9 months on the Daily Living Skills Domain, 7 months on the Socialization Domain, and 2 years 9 months on the Motor Skills Domain, with an Adaptive Behavior Composite of 1 year 7 months. Lori attended a full inclusion preschool on the University of California campus. On her first day of school, Lori's teachers noted that they were unable to take her to the bathroom as she refused to enter the bathroom and covered her ears every time the toilet flushed. Consequently, she had daily toileting accidents at school. Observations at home indicated that she did not react to the toilet flushing at home, which was much quieter. Preintervention probes confirmed that Lori began putting her hands over her ears in the school hallway as the children walked toward the bathroom, about 40 feet away. In addition, she covered her ears and refused to enter the bathroom, even when other children were not present.

Child 2, Jamie, a Caucasian boy, was 2 years and 6 months of age at the start of the study. Recent standardized testing showed the following. On the Vineland Adaptive Behavior Scales, Jamie scored an age equivalent of 1 year 7 months on the Communication Domain, 1 year 6 months on the Daily Living Skills Domain, 1 year 6 months on the Socialization Domain, and 3 years 8 months on the Motor Skills Domain, with an Adaptive Behavior Composite of 2 years 1 month. Prior to the start of services Jamie's mother reported that he could not play with many toys because of his intolerance to certain sounds. Specifically, she reported that he avoided all toys with animal sounds, and when one was turned on he placed his hands over his ears, screamed, cried, and ran away from the toy. Jamie's mother reported that he had been sensitive to sounds all of his life, but at around 2 years of age, he began displaying extreme aversive reactions to the toys. She expressed concern that his play was extremely limited as a result of this behavior. In addition, Jamie became upset at the sight of toys that were associated with animal sounds, and consequently his mother constantly avoided environments where similar toys were available, such as toy stores and friends' homes. In addition, Jamie's mother was concerned that he may display these extreme behaviors in a preschool setting, where these types of toys are common. During preintervention probes collected when in the toy room at the University of California Autism Center, Jamie began to cry at the sight of toys that made animal sounds and repeatedly requested that the toy be put away (i.e., "no, no, no" or "all done"). If the noise was turned on, Jamie engaged in more severe disruptive behaviors, including covering his ears, screaming, crying, and attempting to run out of the room. Prior to intervention, observations were also made at the family's home. Jamie's mother reported that she had put away all of the toys with animal noises as a result of Jamie's severe reaction to the toys and was unwilling to take the toys out for a baseline probe.

Child 3, Jeff, was 2 years and 7 months of age at the start of the study. Jeff was a Eurasian boy who lived with both parents and a younger brother. Recent standardized testing showed the following. On the Vineland Adaptive Behavior Scales, Jeff scored an age equivalent of 1 year 5 months on the Communication Domain, 1 year 5 months on the Daily Living Skills Domain, 9 months on the Socialization Domain, and 2 years 9 months on the Motor Skills Domain, with an Adaptive Behavior Composite of 1 year 5 months. Prior to the start of services, Jeff's mother reported that he appeared to be oversensitive to auditory stimuli, reacting

in a way that suggested such stimuli were intolerable for him. She began noticing his aversive reaction to the sound of vacuum cleaners, blenders, and hand-mixers when Jeff was about 18 months old and reported that his reaction had worsened over time. Consequently, Jeff's apparent hypersensitivity had made a drastic impact on the quality of life for his family. For instance, they often avoided vacuuming their home altogether or began vacuuming only when Jeff was asleep or not in the house. Similarly, they began avoiding other household appliances, particularly the blender and the hand-mixer, that appeared to be painful for Jeff. Finally, they stopped going to Blenders, a family favorite smoothie and juice bar. Jeff's mother adamantly expressed the family's growing concern over his inability to coexist with such stimuli and the inconvenience it caused their family. Preintervention probes were performed in the community and at the family's home prior to the start of intervention. At the mere mention and sight of both the vacuum cleaner and the hand-mixer, Jeff engaged in such behaviors as running away, crying, screaming, forcefully placing his hands over his ears, and grinding his teeth. When either stimulus was turned on, these behaviors greatly increased and intensified. Similarly, a preintervention probe taken at Blenders (smoothie and juice bar) was terminated when Jeff began engaging in the same behaviors in the surrounding shopping center and was unable to enter the store.

Setting

Lori's sessions were all implemented in her full inclusion preschool setting. The students' bathroom was located down the hall from the classroom (about 35 yards). The bathroom had two toilets and two sinks. This was her only setting, because the problem was not observed at any other time. During all of Lori's sessions, a clinician from our center was present while Lori's teacher took her to the bathroom.

Intervention sessions for Jamie were all implemented in a small clinic room located on the University campus. The clinic room contained a large number of children's toys and a small table with chairs. Jamie's mother and a clinician from our center were present during all sessions. In addition, postintervention probes were collected at Jamie's home during follow-up to assess for generalization to a new setting with different toys that also make animal sounds.

For Jeff, sessions for the vacuum cleaner and the hand-mixer took place in the family's home. Preintervention, intervention, and follow-up measures were collected in one of four rooms in his house: the sunroom, playroom, dining room, and living room. Jeff's mother and a clinician from our center were present during all sessions. Sessions for the blender also took place in the family's home and in the same rooms as the vacuum and the hand-mixer. However, additional sessions were implemented at Blenders, Baskin Robbins, and Starbucks stores for generalization.

Design and Procedure

The effects of systematic desensitization on auditory hypersensitivity were assessed within the context of three experimental designs (Barlow & Hersen, 1984). A clinical replication was implemented using a replication of the desensitization procedures for all three children. A changing criterion design was used to systematically advance each child through steps in a desensitization hierarchy. Finally, a systematic replication across three different stimuli (vacuum, blender, and hand-mixer) is presented for Jeff in a multiple baseline.

Baseline

For Lori, data were recorded on her reaction to the toilet flushing when school staff took her to the bathroom. For Jamie, data were recorded on his reaction to the sight and sound of toys that made animal sounds; specifically, a Mattel "See and Say" was used to assess his reaction to these noises during all phases of the intervention. For Jeff, data were recorded on his reaction to the mention, sight, and use of the vacuum cleaner and hand-mixer under normal household conditions while his mother engaged in typical, everyday interactions and activities with her son. Similarly, data were recorded on his reaction to the blender when his mother took him to Blenders.

Intervention

For all three children, intervention steps were developed by a team that included our staff and the individuals who interacted most frequently with the child when the hypersensitivity was occurring. For Lori, this was her teacher; for Jamie and Jeff, these were their mothers. These individuals interacted with the child during intervention while a clinician assisted with the fading steps. The parents and teachers were asked not to move forward in the hierarchy or to present the targeted stimulus to the child without the clinician present, with the exception of Jeff. Jeff's sessions were conducted weekly by the clinician, and Jeff's mother was encouraged to use the most recently completed step in the hierarchy throughout the week if it was convenient for the family and if Jeff appeared comfortable. The clinician kept in close contact with Jeff's mother during the week by telephone and e-mail. For all children, the criterion for completing a step in their respective hierarchies was two to four consecutive 3-minute intervals scored as "comfortable." Specific steps for each child are described below and are presented in Tables 1, 2, and 3 for Lori, Jeff, and Jamie, respectively. Further details pertaining to the length of steps and the number of steps completed per day or per week are described for each child in the Results section.

For Lori, steps 1 through 4 were designed to increase her comfort with the toilet area. Step 1 consisted of

Table 1
Systematic Desensitization Hierarchy for Lori

Step #	Hierarchy Description
1	Toilet is not flushed while Lori walks by the bathroom door. The bathroom door is closed completely.
2	Toilet is not flushed while Lori walks by the bathroom door. The bathroom door is slightly cracked.
3	Toilet is not flushed while Lori walks by the bathroom door. The bathroom door is 1/4 way open.
4	Toilet is not flushed while Lori walks by the bathroom door. The bathroom door is 1/2 way open.
5	Toilet is not flushed while Lori walks by the bathroom door. The bathroom door is completely open.
6	Toilet is flushed repeatedly while Lori is approximately 75 feet from the bathroom door.
7	Toilet is flushed repeatedly while Lori is approximately 50 feet from the bathroom door.
8	Toilet is flushed repeatedly while Lori is approximately 25 feet from the bathroom door.
9	Toilet is flushed repeatedly while Lori is approximately 20 feet from the bathroom door.
10	Toilet is flushed repeatedly while Lori is approximately 10 feet from the bathroom door.
11	Toilet is flushed repeatedly while Lori is at the bathroom door.
12	Toilet is flushed repeatedly while Lori is inside the toilet stall. Door to toilet stall is open.
13	Toilet is flushed repeatedly while Lori is inside the toilet stall. Door to toilet stall is closed.

Table 2
Systematic Desensitization Hierarchy for Jamie

Step #	Hierarchy Description
1	Animal sounds are played repeatedly outside of the clinic room (approximately 20 feet from the door). The clinic room door is closed completely.
2	Animal sounds are played repeatedly outside of the clinic room (approximately 10 feet from the door). The clinic room door is closed completely.
3	Animal sounds are played repeatedly outside of the clinic room (approximately 5 feet from the door). The clinic room door is closed completely.
4	Animal sounds are played repeatedly outside of the clinic room (approximately 4 feet from the door). The clinic room door is closed completely.
5	Animal sounds are played repeatedly just outside of—but held away from—the clinic room door. The clinic room door is closed completely.
6	Animal sounds are played repeatedly just outside of the clinic room and pressed against the clinic room door. The clinic room door is closed completely.
7	Animal sounds are played repeatedly just outside of the clinic room. The clinic room door is slightly cracked.
8	Animal sounds are played repeatedly just outside of the clinic room. The clinic room door is 1/4 way open.
9	Animal sounds are played repeatedly just outside of the clinic room. The clinic room door is 1/2 way open.
10	Animal sounds are played repeatedly inside the clinic room by clinician.
11	Animal sounds are played inside the clinic room by clinician. Jamie spontaneously verbally requests that the clinician play various animal noises.
12	Animal sounds are played repeatedly by Jamie's mother and/or alternated between Jamie and his mother.

having Lori enter the hall when the bathroom door was closed. Steps 2 through 4 were designed to gradually open the door of the bathroom. The remainder of the steps (steps 5 through 13) involved Lori gradually moving closer to the bathroom with the toilet flushing.

For Jamie, the animal sounds were played repeatedly and became increasingly louder as they were gradually moved closer to the playroom where Jamie and his mother engaged in his favorite activities, such as toy play or eating a snack. In steps 1 through 9, Jamie was unable to see the toy playing animal sounds; in steps 10, 11, and 12, he could see and interact with the toy while the animal sounds were played repeatedly. Jamie's systematic desensitization program was completed in one session, and follow-up data were subsequently collected at home. In addition, the clinician kept in close contact with Jamie's mother by telephone and e-mail to discuss Jamie's progress and ability to maintain stable levels of comfort with similar toys at home.

For Jeff, steps 1 and 2 placed a turned-off vacuum, blender, or hand-mixer into his environment and targeted his comfort with seeing the stimulus. Steps 3 through 12 allowed Jeff to become comfortable with the sound of an out-of-sight vacuum, blender, or hand-mixer, becoming increasingly louder as it was moved closer to where he was playing. Finally, in steps 13 and 14, Jeff was able to both see and hear an operating vacuum, blender, or hand-mixer. Jeff's comfort with the blender did not generalize to Blenders; therefore, intervention was also implemented in the community where the smoothie shop was located. Table 4 presents the five additional hierarchical steps necessary for that setting. Step 15 simulated walking into Blenders in the child's home setting. In step 16, a blender was turned off and on repeatedly to approximate the making of juice and smoothies inside the store. Steps 17 and 18 were designed to present the sound of a blender in stores other than Blenders (i.e., Baskin Robbins and Starbucks), and in step 20 Jeff entered Blenders while juice and smoothies were being made.

Table 3
Systematic Desensitization Hierarchy for Jeff

Step #	Hierarchy Description
0	Vacuum/Blender/Hand-mixer is mentioned prior to being used.
1	Vacuum/Blender/Hand-mixer is turned off and placed out of sight in an adjacent room, the sunroom. Jeff is gradually transitioned into the room with the stimulus.
2	Vacuum/Blender/Hand-mixer is turned off and placed in any room Jeff enters. If Jeff remains in any room for an extended amount of time, the stimulus is moved to different locations within the same room.
3	Vacuum/Blender/Hand-mixer is turned on in the back master bedroom. Both the bedroom door and the hallway door are closed.
4	Vacuum/Blender/Hand-mixer is turned on in the back bedroom. The bedroom door is open and the hallway door remains closed.
5	Vacuum/Blender/Hand-mixer is turned on in the back bedroom. The bedroom door is closed and the hallway door is completely open.
6	Vacuum/Blender/Hand-mixer is turned on in the back bedroom. The bedroom door is 1/4-way open and the hallway door is completely open.
7	Vacuum/Blender/Hand-mixer is turned on in the back bedroom. The bedroom door is 1/2-way open and the hallway door is completely open.
8	Vacuum/Blender/Hand-mixer is turned on in the back bedroom. Both the bedroom door and the hallway door are completely open.
9	Vacuum/Blender/Hand-mixer is turned on in the bathroom. Both the bathroom door and the hallway door are completely open.
10	Vacuum/Blender/Hand-mixer is turned on in Jeff's bedroom. The bedroom door is 1/4-way open and the hallway door is open.
11	Vacuum/Blender/Hand-mixer is turned on in Jeff's bedroom. Both the bedroom door and the hallway door are completely open.
12	Vacuum/Blender/Hand-mixer is turned on in the sunroom just outside of Jeff's playroom, yet remains out of sight.
13	Vacuum/Blender/Hand-mixer is turned on in the sunroom just outside of Jeff's playroom and is visible.
14	Vacuum/Blender/Hand-mixer is turned on in the same room as Jeff and is in sight.

Table 4
Systematic Desensitization Hierarchy: Additional Steps Implemented for the Blender for Jeff

Step #	Hierarchy Description
15	Blender is turned on while Jeff and his mother are outside. Jeff and his mother enter the house (where his favorite toys are available) to simulate entering Blenders.
16	Blender is turned off and on repeatedly to simulate sound made at Blenders.
17	Jeff and his mother enter Baskin Robbins while blender is turned on.
18	Jeff and his mother enter Starbucks while blender is turned on at.
19	Jeff and his mother play with his favorite toys near the entrance of Blenders.
20	Jeff and his mother enter Blenders while blender is turned on.

Follow-Up

Follow-up probes were conducted after the completion of intervention for each child under conditions identical to baseline. Follow-up probes for Lori were taken when her teacher took the children to regularly scheduled toileting sessions. Jamie and his mother played together while follow-up probes were taken with both stimuli used during the desensitization program (a Mattel "See and Say" toy) and toys his mother brought in from their home that made animal sounds, and to which he had previously responded negatively. Additionally, follow-up data were collected in the family's home for generalization. Jeff's mother was instructed to engage Jeff in typical, everyday interactions and activities under normal household conditions and data were recorded on Jeff's reaction to the mention, sight, and use of each auditory stimulus.

Dependent Measures

Dependent variables were (a) the number of hierarchical steps completed with the child's anxiety level judged as comfortable per week and (b) the mean level of anxiety per session. Criterion for a step completed was two to four consecutive 3-minute-intervals scored as "comfortable."

An interval recording system (in continuous 10-second intervals) was used to rate the children as appearing comfortable, exhibiting mild or high anxiety, or appearing as if the auditory stimulus was intolerable. *Comfortable* was defined as the absence of any anxiety relating to the stimulus and the child appeared to be relaxed, engaged happily in typical play and interactions, and unaffected by the sight or sound of the stimulus. *Mild anxiety* was defined as engagement in behaviors such as delaying attention to a game or activity,

short whining or whimpering, and brief periods of the child covering his or her ears with his or her hands when the stimulus was introduced. These behaviors briefly delayed but did not interfere with the activity. *High anxiety* was defined as the child exhibiting behaviors such as slowly moving away from the sight or sound of the stimulus, whining, and covering his or her ears to the extent that the child could not participate, play, or interact appropriately. *Intolerable* was defined as the child exhibiting behaviors that suggested that the sight or sound of the stimulus was a painful experience: running away from a game or activity, crying or screaming, pushing his or her hands forcefully over his or her ears, sweating, shaking, and grinding the teeth.

Observer ratings for each 10-second interval were given numeric values (comfortable, 0; mild anxiety, 1; high anxiety, 2; and intolerable, 3). Averages of these scores were calculated every 3 minutes (18 intervals) to obtain a mean anxiety score and plotted as probes along the ordinates in Figures 2, 3, and 4.

Reliability

Using the same interval recording system described above, two undergraduate psychology students, one who was blind to the experimental conditions, independently recorded data for at least 33% of all sessions. Data were scored via videotapes presented in random order. Interobserver agreement was calculated by dividing the number of agreements by the total number of agreements plus disagreements and multiplying by 100. An agreement was defined as both observers rating the child identically (comfortable, mild anxiety, high anxiety, intolerable), whereas a disagreement was defined as any discrepancy between the observers' recordings. Mean interobserver agreement results were 96.8% across all sessions, with a range of 83% to 100%.

Results

During the systematic desensitization intervention program, observers reliably judged all children to become comfortable with increasing steps in exposures to each stimulus. At the end of treatment, each child was judged to be comfortable with the stimulus in sight and operated or turned on. In contrast to baseline sessions, observers never judged the stimulus, at sequential steps, to be intolerable for any of the children once intervention began.

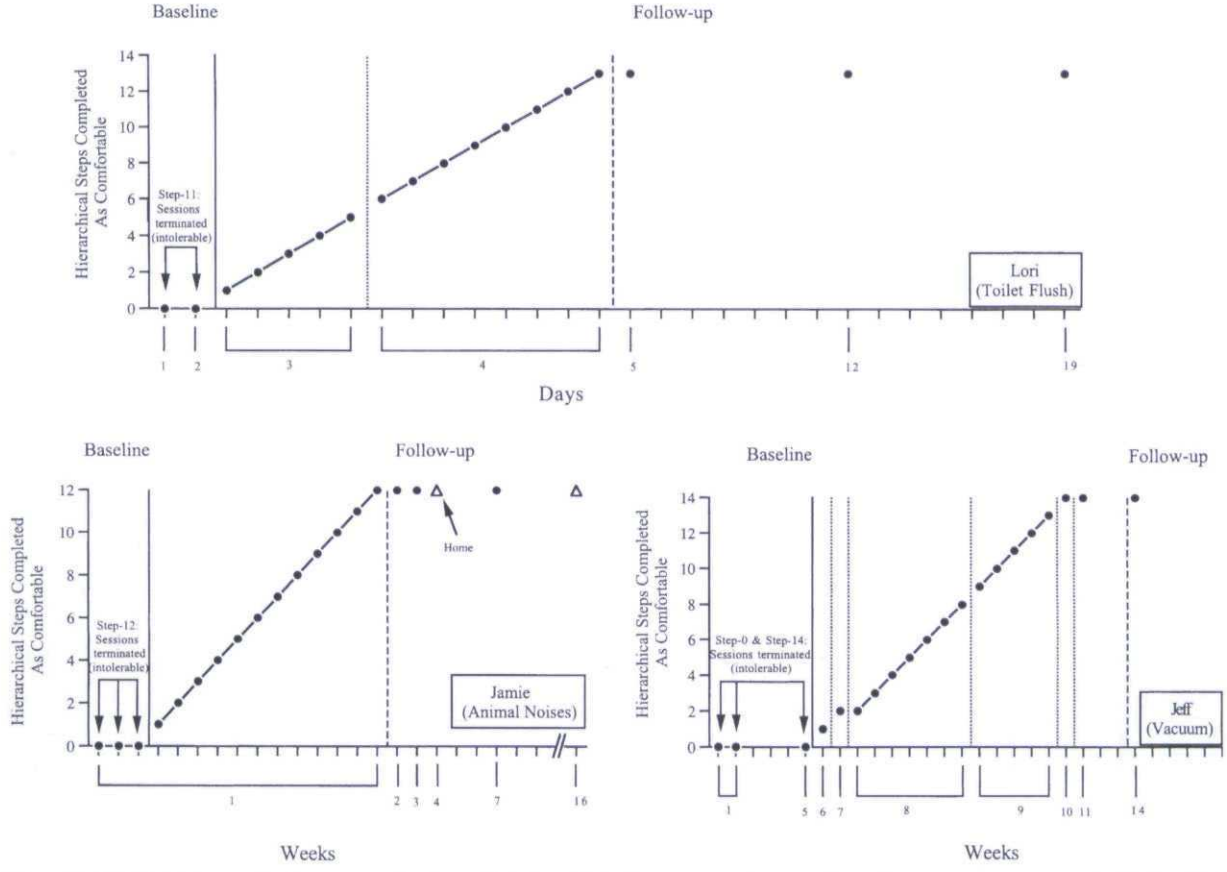


Figure 1. Number of steps in the systematic desensitization hierarchy completed as comfortable per session and per week for each child.

Figure 1 presents the number of hierarchical steps Lori, Jamie, and Jeff completed per week during baseline, treatment, and follow-up conditions for the toilet flush, animal noises, and vacuum, respectively, as a clinical replication. Criterion for a step completed was two to four consecutive 3-minute intervals scored as comfortable.

In the top graph, baseline data indicate that Lori failed to reach criterion levels of comfort at step 11 (toilet is flushed while Lori is at the bathroom door), and sessions were terminated due to behaviors indicating that the toilet flushing was intolerable for her. In contrast, steps completed during intervention reached a stable level of comfort in each session. Completed steps per day ranged from five to eight steps: steps 1 through 5 were completed during day 3 and steps 6 through 13 were completed during day 4. The data show a continuous increase in steps completed. Following intervention, Lori was able to be in the bathroom stall while the toilet was flushed repeatedly. Furthermore, Lori's comfort with the toilet flushing was maintained during follow-up probes taken 1, 8, and 15 days after completing treatment.

In the lower-left graph, baseline data show that Jamie failed to reach criterion levels of comfort at step 12 (animal noise toy is played repeatedly), and sessions were terminated due to behaviors indicating that the animal noise toy was an intolerable stimulus for him. Steps implemented during treatment, however, reached a stable level of comfort in each session. All 12 steps were completed during week 1. Jamie's comfort with the animal noises was maintained during follow-up probes taken 1, 2, and 6 weeks after intervention was completed.

In the bottom-right graph, baseline data indicate that Jeff failed to reach criterion levels of comfort at step 0 (vacuum is mentioned prior to being used) and step 14 (vacuum is turned on and in sight), and sessions were terminated due to behaviors indicating that the vacuum was intolerable for him. In contrast, steps completed during treatment reached a stable level of comfort in each session. Completed steps per week ranged from one to seven: step 1 was completed during week 6, step 2 during week 7, steps 2 through 8 during week 8, steps 9 through 13 during week 9, and step 14 during weeks 10 and 11. The data show a continuous increase in steps completed. Following intervention, Jeff was able to play comfortably with the vacuum nearby, turned on, and in sight. Furthermore, Jeff's comfort with the vacuum was maintained during a follow-up probe taken 3 weeks after completing intervention. Figure 2 presents the number of hierarchical steps Jeff com-

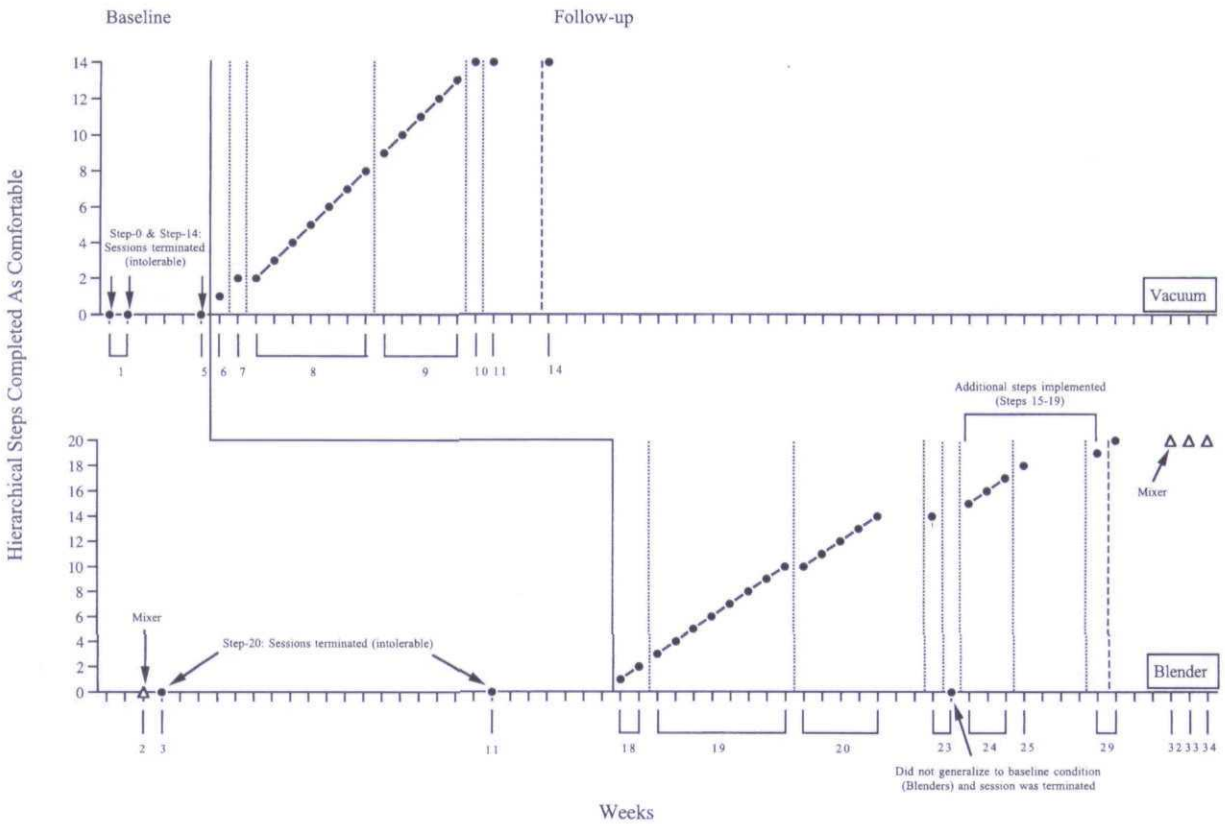


Figure 2. Number of steps in the systematic desensitization hierarchy completed as comfortable per session and per week for the vacuum, blender, and hand-mixer for Child 3 (Jeff) presented in a multiple baseline across stimuli design.

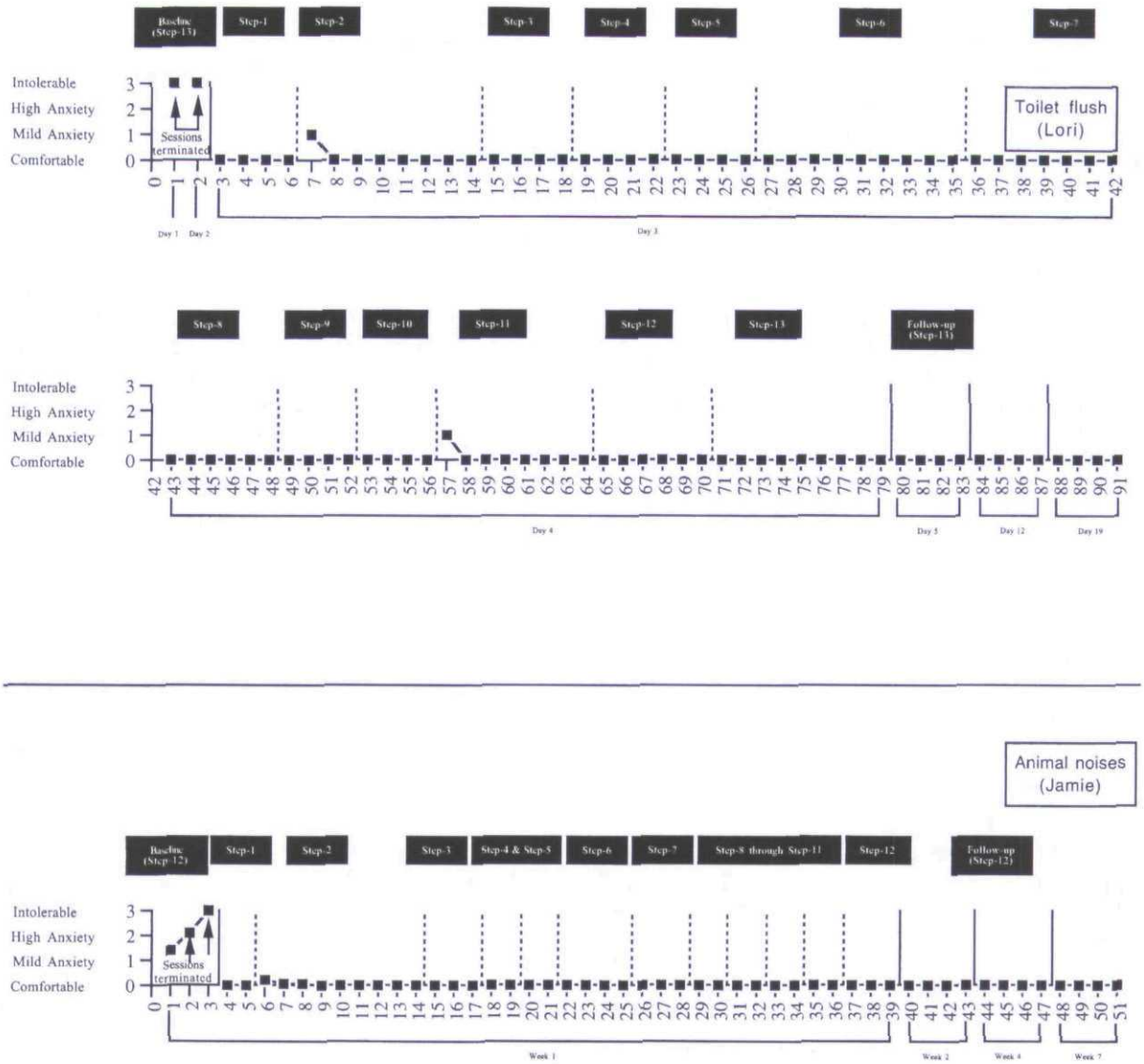
pleted per week during baseline, intervention, and follow-up conditions across auditory stimuli in a multiple baseline. In the bottom graph, baseline data show that Jeff failed to reach criterion levels of comfort at step 20 (Jeff goes to Blenders while juice/smoothies are being made), and sessions were terminated due to behaviors indicating that the blender was an intolerable stimulus for him. Additionally, a single baseline point indicates that Jeff failed to reach criterion levels of comfort at step 14 for the hand-mixer (hand-mixer is turned on and in sight), and the session was terminated due to behaviors indicating that the hand-mixer was yet another intolerable stimulus. Data collected during intervention showed that Jeff reached a stable level of comfort at each step in the desensitization hierarchy. Completed steps for the blender ranged from one to eight steps per week: steps 1 and 2 were completed during week 18, steps 3 through 10 during week 19, steps 10 through 14 during week 20, step 14 during week 23, steps 15 through 17 during week 24, and step 18 during week 25. Generalization probes during week 23 demonstrated that Jeff's comfort with the blender at home did not generalize to Blenders, so the session was terminated. Thus, additional steps (steps 15 through 19) were created and implemented. These additional steps led to generalization at Blenders (steps 19 and 20) during follow-up probes taken 4 weeks after completing intervention. The bottom graph of Figure 2 also shows generalization probes taken to evaluate Jeff's reaction to the hand-mixer during week 32. Without intervention for the hand-mixer, Jeff reached criterion levels of comfort at step 14 (hand-mixer is turned on in the same room and in Jeff's sight), thereby demonstrating generalization. Additional probes were taken during week 33 and 34, in which Jeff again reached criterion levels of comfort with the hand-mixer turned on and in sight.

Figure 3 presents Lori and Jamie's mean level of anxiety observed during the increasing hierarchical step for the toilet flushing and animal noises, respectively.

In the top graph, baseline probes indicate that toilet flushing caused observers to judge that the toilet was an intolerable stimulus for Lori. Sessions on both days were terminated because of her severe reaction to the toilet flushing. During intervention, anxiety levels decreased from mild anxiety to comfortable and remained relatively stable in the comfortable range following completion of steps 1 and 2. The number of intervals to reach criterion for a step completed as comfortable ranged from four to nine. During the first day of intervention, step 1 was used and Lori's anxiety was judged to be in the comfortable range for four 3-minute intervals, meeting the criterion to advance to the next step. In step 2, however, Lori's anxiety was initially judged as mild for one interval before reducing to comfortable for the next seven intervals, thereby reaching criterion. Lori was able to move from steps 3 through 7 on the same day, and her anxiety was reliably observed as comfortable. On day 2 of intervention, Lori's anxiety was judged to be comfortable in steps 8 through 10. In step 11, her anxiety was initially judged to be mild for one interval before again reducing to comfortable for the next seven intervals. Observers continued to judge Lori as comfortable during steps 12 and 13, thereby completing the hierarchy. Step 13 was repeated at follow-up during days 5, 12, and 19, and Lori again was observed to be comfortable, remaining stable for four consecutive intervals on each day.

In the bottom graph, baseline probes indicate that the Mattel "See and Say" animal noises toy caused observers to judge that the toy was an intolerable stimulus for Jamie. Sessions were terminated because of his severe reaction to the noise. During intervention, anxiety levels were judged in the comfortable range and remained relatively stable. The number of intervals to reach criterion for a step completed as comfortable ranged from two to nine. During week 1, step 1 was used and Jamie's anxiety was judged to be in the comfortable range for two intervals, meeting the criterion to advance to the next step. In step 2, Jamie's anxiety was initially judged as mild for one interval before reducing to comfortable for the next eight intervals, thereby reaching criterion. Jamie was then able to move from steps 3 through 12 during the rest of week 1, and his anxiety was reliably observed as comfortable. Step 12 was repeated at follow-up during weeks 2, 4, and 7, and Jamie again was observed to be comfortable, remaining stable for four consecutive intervals on each day.

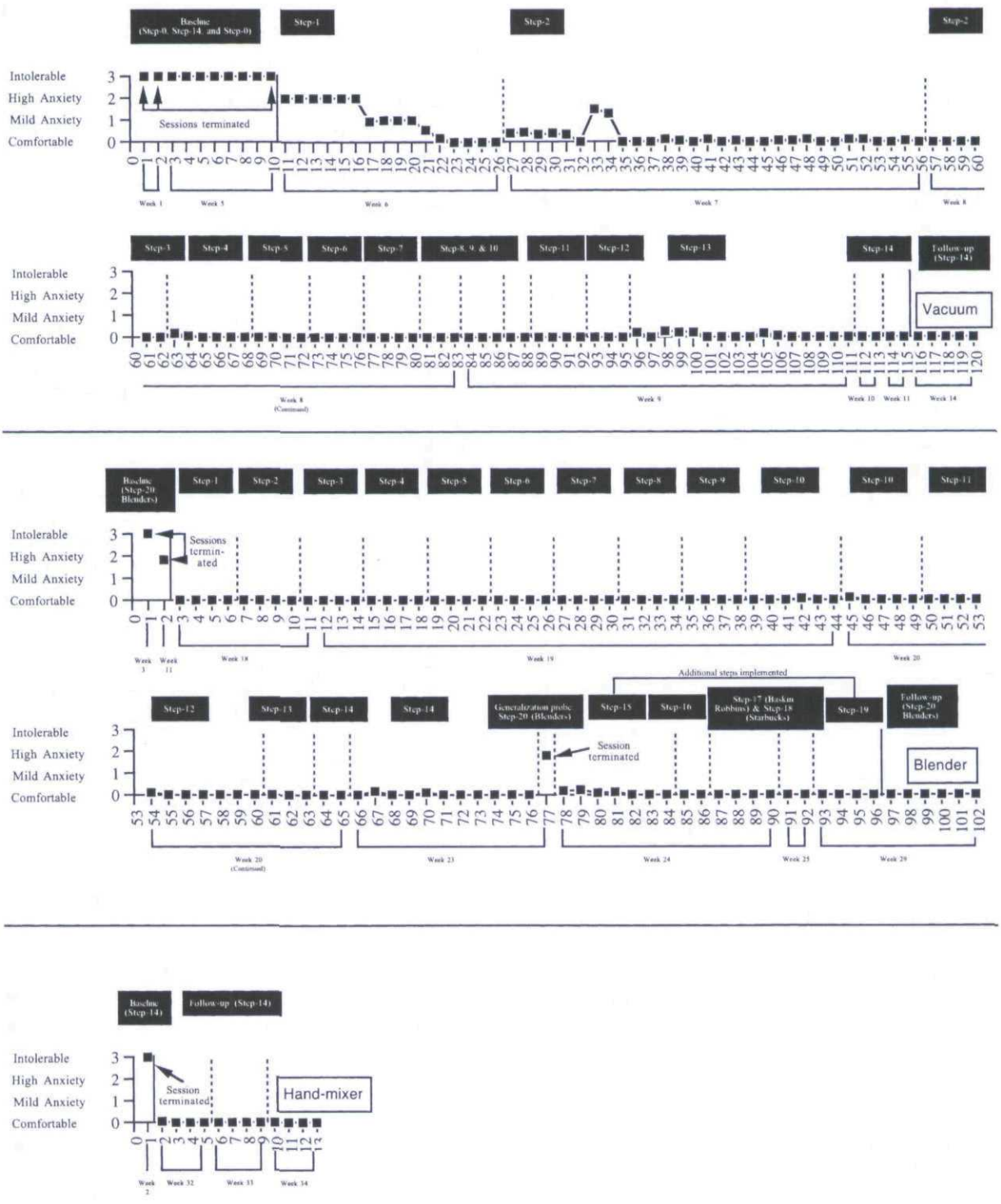
Figure 4 presents Jeff's mean level of anxiety—ranging from comfortable to intolerable—observed during the increasing hierarchical steps for the vacuum, blender, and hand-mixer. In the upper-left tier of the top graph, baseline probes indicate that both mentioning the vacuum and turning it on caused observers to judge that the vacuum was an intolerable stimulus for Jeff. During the first baseline probe, mention of the vacuum produced behaviors suggesting that it was an intolerable stimulus, and the session was terminated. The second baseline probe shows Jeff's intolerance with the vacuum when it was turned on; thus, the session was again terminated. Finally, the vacuum was mentioned once more during the third baseline probe, and the session was terminated following stable levels of behavior again suggesting to observers that it was an intolerable stimulus. During intervention, anxiety levels decreased from high anxiety to mild anxiety to comfortable and remained relatively stable in the comfortable range following completion of step 2. The number of intervals to reach criterion for a step completed as comfortable ranged from 2 to 34. During week 6, step 1 was used and Jeff's anxiety initially was judged to be high for six consecutive intervals. His anxiety reduced to mild for the next four intervals before reducing again to comfortable and reaching criterion for the final four



*Criterion for a step completed is 2-4 consecutive three-minute intervals scored as comfortable

Figure 3. Mean level of anxiety per 3-minute interval in each hierarchical step for toilet flush for Child 1 (Lori) and animal noises for Child 2 (Jamie).

intervals. Jeff was able to move up to step 2 during week 7, and his anxiety was reliably observed as low, with the exception of an increase to high anxiety during two intervals. Criterion was not met for step 2 during week 7; thus, this step was reintroduced during week 8 until criterion was met after four consecutive intervals were judged as comfortable. Jeff's behavior was observed to be comfortable during both intervals of step 3 and in the low anxiety to comfortable range during step 4. Levels of comfort remained stable through the rest of the intervals in steps 5 through 8. Observers continued to judge Jeff as comfortable during steps 9 through 12 the following week. In step 13, his anxiety was initially judged to move in and out of the comfortable range before remaining comfortable for the final five intervals. Jeff completed step 14 (vacuum is turned on, in



*Criterion for a step completed is 2-4 consecutive three-minute intervals scored as comfortable

Figure 4. Mean level of anxiety per 3-minute interval in each hierarchical step for the vacuum, blender, and hand-mixer for Child 3 (Jeff).

sight, and in the same room) during weeks 10 and 11. Step 14 was repeated at follow-up, and Jeff again was observed to be comfortable and remained stable for five consecutive intervals. In the upper-left tier of the middle graph, baseline probes show that going to Blenders (step 20) elicited behaviors suggesting that the blender was an intolerable stimulus, and the session was terminated. Following intervention of the vacuum during week 11, a second probe taken at Blenders (step 20) was taken for generalization and indicated that going to Blenders continued to produce behaviors that suggested the blender was causing high anxiety, and the session was again terminated. During intervention, anxiety levels decreased from intolerable to high, then to mild, before remaining relatively stable in the comfortable range. The number of intervals to reach criterion for a step completed as comfortable ranged from 2 to 11. Observers judged Jeff to remain in the comfortable range for steps 1 through 9. During week 19, Jeff was observed to be comfortable for three intervals of step 10 before he was judged to have mild anxiety for one interval. Although Jeff quickly returned to the comfortable range for the following two intervals, step 10 was repeated during week 20. His anxiety initially was judged to be mild for one interval before reducing to comfortable and reaching criterion for the final four intervals of step 10. Observers judged Jeff to be comfortable throughout step 11 and then to demonstrate low levels of anxiety during the first interval of step 12 before returning to comfortable for six consecutive intervals. Thus, Jeff was systematically advanced to steps 13 and 14. Step 14 was repeated during week 23, and his anxiety was initially judged to move in and out of the comfortable range before remaining comfortable for the final six intervals. A generalization probe was then taken at Blenders in which judges observed Jeff's behavior to be in the high anxiety range. Thus, steps 15 through 19 were implemented to more closely simulate Blenders. During step 15, Jeff's anxiety was initially judged to be low before remaining comfortable for the final three intervals. Levels of comfort remained stable for steps 17 through 19. The final test of whether general-case procedures would be effective was used at follow-up, where step 20 (Blenders) was repeated and Jeff was observed to be comfortable and remained stable for five consecutive intervals. The bottom graph presents the results of a further test of whether general-case procedures would produce a generalized level of anxiety reduction to this type of auditory stimuli. The upper-left tier of the graph shows a baseline probe indicating that turning on the mixer (step 14) caused observers to judge that the mixer was an intolerable stimulus for Jeff, and the session was terminated. Following intervention for the blender, a second probe of the mixer (step 14) was taken for generalization during week 32. Initially, observers judged Jeff's behavior to be in the mild anxiety range before remaining stable in the comfortable range for three consecutive intervals. Step 14 was used again in week 33 and week 34, in which observers reliably judged Jeff to remain comfortable for four intervals. Overall, the data show that anxiety levels remained low throughout intervention for the vacuum and the blender and at follow-up for the hand-mixer. Thus, observers judged Jeff as comfortable throughout much of the intervention and able to maintain comfort in the presence of an operating vacuum, blender, and hand-mixer.

Discussion

These results suggest that the intense reactions to auditory stimuli many children with autism exhibit may be related to a phobia rather than pain associated with a stimulus. Specifically, the extreme reactions the children displayed at baseline (running away from various auditory stimuli, loud and severe screaming, forcefully covering ears, sweating, shaking, and grinding teeth) might easily have suggested that the children were in pain. However, the data indicate that hypersensitivity to the sound of the stimuli may have been a conditioned response that could be treated with a counterconditioning behavioral intervention (systematic desensitization) typically used to treat phobias in children (Center, 1989).

As mentioned earlier, it has been reported that many children with autism seem to have hypersensitive hearing (Grandin & Scariano, 1986; Hayes & Gordon, 1977; Ney, 1979; Rimland, 1964; Rimland & Edelson, 1995). The current study suggests that if hypersensitivity is indeed causing children with autism to display aversive reactions to auditory stimuli, then hypersensitivity is more complex than we originally thought, yet relatively easy to overcome. Clinically, whether such reactions are due to hypersensitive hearing or an unrelated phobia, this study suggests that children may respond favorably to the same type of intervention (systematic desensitization). Theoretically, though, if the children's intolerant reaction to aversive auditory stimuli were entirely due to hypersensitivity, their responses would be relatively unchangeable with desensitization, or at least not likely to move into the comfortable level. The data, however, show that the responses of all three children could be quickly and easily modified to the point where they appeared completely comfortable. Following intervention and at follow-up, all children were reliably rated to be comfortable in the presence of operating auditory stimuli that at baseline appeared to be intolerable. Thus, the children not only tolerated the sight and sound of these stimuli but also displayed behaviors that suggested they were comfortable (i.e., playing, smiling, laughing, and interacting with mother or therapist appropriately). Again, these results indicate that each child's initial reaction to aversive auditory stimuli may have been phobic rather than painful. Thus, the

data extend reports of phobias in children with autism (Howlin et al., 1973; Jackson & King, 1982; Love, Matson, & West, 1990; Luiselli, 1978) to include the extreme reactions they display in the presence of auditory stimuli.

Further indicating that the intense reactions to auditory stimuli were related to a phobia was Jeff's ability to drink a Blenders smoothie at follow-up. In describing procedures of desensitization, Wolpe (1973) suggested that there were incompatible responses to fear and anxiety. In addition to relaxation and sexual arousal, digestion has been reported to be incompatible with fear. In all baseline sessions and in the generalization probe taken during week 23, Jeff would not drink his smoothie, even if offered to him outside of the store or in the car on the ride home. At follow-up, however, Jeff accepted the drink from his mother and appeared comfortable while consuming the entire smoothie. This observation supports the finding that Jeff's intolerant reaction to auditory stimuli—which initially appeared to be related to pain associated with the stimulus—may have been a conditioned response.

The exact nature of the original conditioning, as with most phobias, is difficult to determine. In future research, it might be interesting to attempt to understand whether, or how, such conditioning occurred. One possible explanation for such conditioning may be stimulus overselectivity, a deficit in children with autism that has been validated empirically (Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas, Schreibman, Koegel, & Rehm, 1971; Reynolds, Newsom, & Lovaas, 1974). In other words, children with autism often respond to only one component of a stimulus, which seems to prevent them from acquiring and generalizing behaviors (Lovaas, Schreibman, Koegel, & Rehm, 1971). It is possible, then, that overselectivity may have caused the children to attend only to auditory stimuli and prevented them from responding to other and more relevant components of their environment. While young, typically developing children may become frightened by loud noises (e.g., vacuums, blenders, and hand-mixers), auditory overselectivity may have caused the children in this study to fail to associate the auditory stimuli with positive reinforcers. Thus, the children's reactions to auditory stimuli may have been a conditioned phobic response due to their inability to respond to other stimuli in their environment.

This explanation is further supported by the intervention for stimulus overselectivity: teaching responsivity to multiple cues (Koegel & Schreibman, 1977; Schreibman & Koegel, 1982). Although competing reinforcers (i.e., small treats and snacks, toys and activities, and social interaction games) were used as anxiety inhibitors, they may have simultaneously taught the children to respond to multiple stimuli while auditory stimuli were gradually and systematically introduced into their environments. As each child learned to respond to both the competing reinforcers and auditory stimuli, their responses to auditory stimuli may then have been counterconditioned, allowing them to seem comfortable in the presence of such stimuli. This hypothesis also is consistent with other similar theories of perceptual dysfunction in children with autism (Courchesne, Yeung-Courchesne, & Pierce, 1999; Cox & Schopler, 1993; Ritvo, 1983; Schopler, 1978; Schopler & Mesibov, 1995).

In addition to having theoretical importance, the children's ability to become comfortable with stimuli that were judged to be intolerable is socially significant. For example, as noted earlier, the children's reactions to the common stimuli negatively affected their (and often their family's) ability to participate in everyday settings. Following intervention, they were able to participate in all settings and the families did not need to avoid specific settings or alter their lifestyles because of possible negative effects they may have on their child. Jeff and Jamie's mothers reported that they both felt personal anxiety about the stimuli causing apparent pain to the child, and that the absence of any intense reaction related to the auditory stimulus following intervention had greatly improved the family's quality of life.

Overall, the current study suggests that one cause for extreme responses to auditory stimuli may be due to the development of phobias. Thus, next steps in this type of research might be to look at whether there are multiple causes to children with autism's extreme reactions to auditory stimuli and to examine the generality of changes. In any case, the results of the current study suggest that a hierarchical desensitization program may be helpful in eliminating apparent sound sensitivities in children with autism.

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