**Assessment and treatment of noise hypersensitivity in a teenager with Autism Spectrum Disorder: A Case Study.**

by

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**Abstract**

Noise hypersensitivity is a poorly understood symptom of Autism Spectrum Disorder (ASD). For some, problem behaviors co-occur with the aversive noise. Limited literature exists on treating noise hypersensitivity; however, noise hypersensitivity may be related to a specific phobia. This case study utilizes modified Cognitive Behavioral Therapy (CBT) to address anxiety, avoidance, and problem behaviors evoked by noise in a teen with ASD and mild Intellectual Disability (ID). Using multi-method assessment and individualized treatment, problem behaviors reduced, and independent coping strategies use occurred. Successful desensitization supports the efficacy of modified CBT as a treatment for noise-related anxiety and problem behaviors in individuals with ASD and ID. Outcomes are discussed considering intervention difficulties for noise hypersensitivity in a complex and diverse population.

*Keywords:* Autism Spectrum Disorder; Cognitive Behavior Therapy; systematic desensitization; noise hypersensitivity; problem behaviors; anxiety

**Assessment and treatment of noise hypersensitivity in a teenager with Autism Spectrum Disorder: A Case Study.**

Individuals diagnosed as having an Autism Spectrum Disorder (ASD) exhibit significant deficits in the areas of communication and socialization, as well as excesses in the areas of repetitive behaviors and circumscribed and intense interests (American Psychiatric Association, 2013). One core symptom commonly reported, yet poorly understood, is sensory sensitivity, especially to noises. Sensory sensitivity is a pattern of atypical responses to information from the senses. Sensory sensitivities can be characterized as either hypersensitivity, an exaggerated response to sensory information, or hyposensitivity, a less intense than expected response to sensory information (Baranek et al., 2006). It is well established that children with ASD commonly have hypersensitivity or hyposensitivity to noise stimuli (Baranek et al., 2006; Jones, 2003); however, little is known about how best to assess and treat noise sensitivity.

Over half of all individuals with ASD experience some form of sensory hypersensitivity (Baranek et al., 2006; Mazurek et al., 2013). Further, approximately 40% of children with ASD show signs of noise hypersensitivity, which is significantly higher than the rate in children without ASD (Lucker ,2013; Rimland & Edelson, 1995). For some with ASD, problem behaviors (e.g., self-injury, aggression) are associated with hypersensitivity to noise (Stiegler & Davis, 2010; Iwata et al., 1994). Iwata et al (1994) proposed that auditory hypersensitivity might serve as an establishing operation, thus altering the value of escape as a reinforcer, and increasing the likelihood of an individual engaging in problem behaviors. Additionally, a case report involving systematic desensitization to address auditory hypersensitivity proposed that auditory hypersensitivity might be conceptualized as similar to a specific phobia (Koegel, 2004). That is, problem behaviors associated with auditory stimuli may reflect activation of the fight or flight response in response to exposure to a feared stimulus. Further, individuals with ASD who have noise hypersensitivity have self-reported experiencing significant anxiety when they hear a “feared” sound, and due to the intense physiological arousal they experience they may attempt to avoid or escape that situation even if it leads to negative consequences or social isolation (Landon, Shepherd, and Lodhia,

2016). Given data suggesting that noise hypersensitivity in those with ASD could be conceptualized as an anxiety disorder, but more so a specific phobia (Green and Ben-Sasson, 2010; Koegel et al, 2004; Landon et al., 2016; Stiegler and Davis, 2010), it may be reasonable to assume that incorporating relevant assessments and treatments could have some utility.

While research suggests that anxiety commonly co-occurs with ASD (Kim et al., 2000; Kirsch et al., 2020; White, Oswald, Ollendick, & Scahill, 2009), assessing symptoms of anxiety in those with ASD can be especially challenging. Specifically, anxiety can look different in those with ASD, potentially only presenting as externalizing behaviors (e.g., aggression, elopement, self-injury) or simply as an increase in symptoms which are considered core autism symptoms (e.g., social withdrawal, stereotypical motor movements, ritualistic patterns of behavior) (Kerns & Kendall, 2010). Further, children with ASD may have limited emotional processing and difficulty identifying and describing feelings which may hinder their ability to accurately self-report mood or physiological sensations. This is even more confounded in children with ASD who also have co-occurring intellectual disabilities and/or impaired verbal abilities. Additionally, complicating diagnosis is the fact that some symptoms of anxiety overlap with the core features of ASD and are even presumed to be better explained by ASD, such as social avoidance behaviors and inattention (White et al., 2009). This highlights the need for a modified, tailored approach to the diagnosis and assessment of anxiety in individuals with ASD who may not be able to fully verbalize emotions (Hagopian & Jennett, 2008). Incorporating the use of multiple measures and methods of assessment, such as physiologic measures (heart rate, blood pressure), coding of fearful affect, observation of avoidance behavior, and self-reports can be critical to diagnosis and subsequent treatment of anxiety in children (Davis & Ollendick, 2005).

Cognitive behavioral therapy (CBT) is an empirically supported psychological treatment for anxiety and mood disorders in children. Systematic desensitization, a major component of CBT for anxiety disorders, involves combining teaching relaxation and other coping strategies with gradually exposing an individual to increasingly more aversive levels of the feared stimulus. The goal of systematic desensitization is extinction, or at least a marked reduction, in the person's extreme physiological arousal

and negative response to aversive stimuli (Ollendick & King, 1998). Guidelines on how to modify CBT for individuals with ASD have been published (Beck Institute, 2015); however, very few demonstrations of modified CBT for those with ASD exist. Multiple studies have demonstrated the success of CBT in persons with ASD who are higher functioning, but there is a dearth of evidence for the effectiveness of CBT techniques in children with more severe ASD or for children with co-occurring intellectual disability (Moree, 2009). In the past, applied behavior analytic interventions for problem behaviors in ASD has often used techniques that involved reinforcing the absence of the problem behavior or using headphones to avoid stimuli (Ikuta et al., 2016; McCord, Iwata, Galensky, Ellingson, & Thomson, 2001; Severini, Ledford, & Robertson, 2018). However, Stiegler and Davis (2010) suggested that avoidance of sounds might cause longstanding issues with tolerating sound in individuals with ASD. This research in combination with the goal of increasing self-advocacy by teaching individuals to self-regulate and cope with aversive circumstances is critical. Therefore, focusing on skill building through CBT as a support for reducing physiological distress instead of simply promoting reduction of undesired behaviors via avoidance may be more beneficial long-term, and is more in line with contemporary values for self-determinism among individuals with ASD (Cheak-Zamora et al., 2020).

In this article, we report a case study of a teen diagnosed with ASD and co-occurring intellectual disability who engaged in severe problem behaviors related to hypersensitivity to certain noises. The case, while complex, provides a demonstration of the intricacies and modifications that may be necessary to best suit the needs of this widely variable patient population.

## Method

### *Participant*

"Aaron" was a 16-year-old male diagnosed with mild intellectual disability and ASD. He was admitted to an intensive, outpatient hospital-based clinic for the assessment and treatment of severe problem behavior. His hearing had been previously found to be in the normal range, and central auditory processing disorder had been ruled out based upon a thorough assessment by a community-based audiologist and speech language pathologist.

He was able to communicate using flexible and developmentally appropriate language. Aaron was mainstreamed in a public high school with individualized program supports.

At intake, Aaron's mother reported severe problem behaviors (i.e., self-injury [SIB], defined as forcefully hitting himself on the sides of head or chest; and physical aggression [AGG], defined as hitting, choking, or kicking others with force, and throwing items at others) and avoidant behaviors (i.e., elopement, screaming/yelling, crying, covering his ears, "freezing" or contorting his body in odd ways, and an increase in hand/motor stereotypy) in the presence of a variety of loud noises, particularly sounds of small children crying or having tantrums. Reportedly, within the 6 months prior to admission, Aaron frequently attempted to aggress toward children who were making loud noises, such that caregivers had to prevent him from causing injury using strategies light staying within arm's reach, removing him from the situation, and physical pressure/mild; however, on three separate occasions, he was able to successfully hit, choke, and/or shake the child he targeted.

*Setting*

Initially, assessment and treatment sessions were conducted in a 4.4m x 4.8m room with a one-way observation window. To create an environment similar to that of Aaron's home or community, leisure items were placed on the table to allow opportunities for physical aggression (e.g., throwing items at the therapist). An audio receiver, two laptop computers, and sound amplifier were located in an adjoining observation room. Five speakers connected to the audio receiver were mounted in the ceiling of the padded room for evenly distributed sound. A sound level meter measured noise level (in decibels) and an electronic timer measured session time.

A Polar FT1 heart-rate monitor, consisting of a wristwatch (worn by the therapist) and strap around Aaron's ribcage and underneath his shirt, measured heart rate (HR). Informal probe sessions indicated Aaron tolerated the equipment without problem behavior and established his resting HR at approximately 72.5 beats per minute (bpm) which is within a normal range for his age (Reusz et al, 2010). A therapist or Aaron's mother placed the HR monitor on him at the beginning of visits where HR data was collected; the monitor was worn across all session and rest periods. Prior to each session, a monitor

check was completed to ensure that the monitor was calibrated. As the therapist wore the wristwatch, Aaron was not shown his heart rate data. He was not observed to touch the heart rate monitor during assessment or treatment evaluation sessions.

Generalization probes were conducted first in areas of the outpatient clinic, and then in the participants' home. Final probes were conducted in-vivo in community settings previously identified as problematic (i.e., mall, community swimming pool, bowling alley, Babies"R"Us).

## Study 1: Assessment of Phobic Avoidance of Noise

A functional behavioral assessment comprised of indirect and direct assessments was conducted to examine features of and underlying variables maintaining reported problem behavior and to identify the most relevant noise stimuli.

### Indirect Assessments

All indirect assessments were administered at intake via interview with Aaron's mother.

**Anxiety Disorders Interview Schedule – 4th edition; Parent Edition (ADIS-IV-P).** The ADIS-IV-P is a semi-structured diagnostic interview assessing psychopathology (based on DSM-IV categorical scheme) in children and adolescents ages 7 – 17 years (Silverman & Albano, 1996). The specific phobia module of the ADIS-IV-P was administered. Severity of each phobia diagnosis was assigned a clinician severity rating (CSR) on a scale from "0" (none) to "8" (very severely disturbing/disability), with a CSR 4 (definitely disturbing/disability) considered clinically significant, warranting a diagnosis. The inter-rater reliabilities of the ADIS-IV-P have been found to be acceptable (parent interview, $\kappa = 0.77$; Grills & Ollendick, 2002).

**Questions About Behavioral Function (QABF).** The QABF is a 25-item questionnaire designed to assess variables maintaining challenging behavior in individuals with intellectual and developmental disabilities. Each item is rated on a four-point Likert-type scale with respect to the target behavior(s) frequency and severity for five categories reflecting functions that maintain challenging behavior: attention, escape/avoidance, non-social, physical/pain, and tangible. Frequency scores reflect the number of items endorsed in that specific category (e.g., attention), with a maximum score of 5. The severity

score for each category is the sum of Likert endorsement scores for each item; each category has a maximum severity score of 15. Higher frequency and severity scores are more indicative of a maintaining function for the targeted behavior. The QABF has been found to be a reliable instrument with moderate to excellent test-retest and inter-rater reliability correlations ranging from .79 to .99 (Paclawskyj, Matson, Rush, Smalls, & Vollmer, 2000).

**Results of Indirect Assessments**

*ADIS.* Noise associated with the highest CSR rating was "babies/children crying and tantrumming" (CSR = 8), followed by thunder (CSR = 6), sirens (CSR = 5), fireworks (CSR = 4), and dogs barking (CSR = 4); all ratings were clinically significant.

*QABF.* The escape/avoidance category obtained the highest possible score on the frequency (score = 5) and severity (score = 15) scales indicating the hypothesized primary function of target problem behavior (i.e., SIB and AGG) was escape or avoidance. Physical/pain was also noted to possibly be secondarily related to occurrence of problem behavior (frequency = 3; severity = 6).

**Direct Assessments**

**Direct Observation of Anxiety Assessment.** A preliminary assessment based on the procedures of McCord et al (2001) and Dadds et al (1996) was undertaken to identify noises most likely to evoke avoidance behavior and/or problem behavior, using the five noises rated as having a CSR above 4: screaming/crying baby, dog barking, fireworks, sirens, and thunder. White noise was included as a control.

The initial decibel levels were based on established normative parameters (Northern & Downs, 1978) at 55 dBs. Two other dB levels were also assessed: 70 dBs and 85 dBs. The three dB levels were used for four reasons: 1) to serve as distinctly different from each other in audible intensity; 2) to see what dB levels were most associated with target behavior; 3) to see which noises were most consistently associated with target behaviors across all dB levels; and 4) to mimic the naturally occurring dB levels of certain stimuli (e.g., the dB level of a large dog barking can exceed 100 dB).

*Procedure.* Each session was 5 minutes, separated by 2 to 5 minutes to prevent carryover effects, and during each session only one type of noise was presented. When a session began, the taped noise was played continuously but was stopped for 30s contingent upon the occurrence of problem behavior.

*Response Measurement.* Behavioral data for problem behaviors and phobic avoidance behaviors were collected in-vivo with the therapist by trained observers using a 10-s partial interval recording procedure.

*Observer Measures.* Aaron's SIB was defined as attempts or successes at punching himself in the head or body; pulling his hair; biting his hands; and bending his fingers back more than 45 degrees. Physical aggression was defined as attempts or successes at forcefully hitting, kicking, pushing, pinching, head butting, body slamming, throwing objects at, or choking others. Disruptive behavior was defined as attempts or successes at banging with force on walls/furniture, throwing items not directed at others, and ripping or breaking items. Phobic avoidance behavior was defined as elopement, facial grimacing, crying for 3 seconds (s) or more (with tears), yelling/screaming for 3 s or more, nail-biting, covering ear(s) for 3 s or more, arm/body stereotypy, and trunk contortions.

*Physiological Measures.* HR was measured every 30 s by the in-room therapist. Readers may request raw heart rate data (prior to tabulating mean HR) by contacting the corresponding author.

*Interobserver Reliability (IOA).* During the direct observation of anxiety assessment and treatment evaluation two observers independently collected data for 75% of sessions. IOA was calculated on an interval-by-interval agreement basis by dividing the number of intervals with agreement by the number of total intervals and multiplying that number by 100%. Across the assessment, IOA values averaged 96.4% for total problem behavior (i.e., SIB + AGG: range = 83% to 100%) and 89.7% for total phobic avoidance (i.e., Anxiety + Avoidance; range = 83.0 – 100).

**Results of Direct Assessments**

Results of the DOA Noise Assessment are shown in Figure 1. Relative to the control condition

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Insert Figure 1 here

(i.e., white noise), the noise stimulus of a baby tantruming/crying was associated with the highest percentages of intervals of problem behavior (3.3, 6.7, 16.7%), and avoidance (100%) and anxious behavior (40.0, 100.0, 100.0%) , as well as increased average HR (79.4, 89.0, 111.9 bpm) across all decibel levels. A second noise stimulus, thunder, was also associated with consistently with elevated problem behavior (3.3. 6.7, 10.0%), avoidance (70.0, 100.0, 100.0%) and anxious behaviors (50.0, 60.0, 60.0%) , and HR (81.9, 85.7, 95.0 bpm). Elevations in avoidance and anxious behaviors were observed across other noise stimuli (i.e., dogs barking, firework, and sirens), most often at the highest decibel level; however, these stimuli were not associated with consistently increased levels of anxious and avoidance behaviors; were associated with zero rates of problem behaviors; and did not evoke increased HR across all noise volume levels. As such, the noises of a baby tantruming/crying and thunder were utilized for further assessment and intervention.

## Study 2: Functional Analysis

A functional analysis (FA) was conducted based on the procedures of McCord and colleagues (2001) to determine if problem and phobic avoidance behavior occurred to escape aversive noises. The following conditions were evaluated in a multi-element design: noise, no noise/ignore, and continuous social interaction. Each session was 5 min, and conditions occurred in a nested, random sequence. During the noise condition, the therapist was present but did not interact with Aaron, and a tape of a baby having a tantrum was played at 85 dBs. Contingent upon the occurrence of targeted problem behavior or avoidance/anxiety, the therapist stopped the tape for 30s. In the no noise/ignore condition, a therapist was present but did not interact with the participant. In the continuous social interaction condition, a therapist delivered continuous verbal attention (e.g., social conversation, praise statements) in a normal conversational tone. Occurrences of problem behavior were ignored. No noise was played during the ignore and continuous social interaction conditions.

*Response Measurement and Reliability.* Occurrences of problem and phobic behaviors were recorded as described previously, and the same methods were used for calculating IOA. A second

observer recorded data on combined targeted behavior for 50% of sessions; IOA averaged 97.5% (range, 90% to 100%). Reliability for sound level was assessed during 50% of the sessions and there was 100% agreement.

*Results.* Results of the FA are shown in Figure 2 with percentage intervals of problem behavior (i.e., SIB + AGG) shown in the top panel and percentage intervals of anxiety and avoidance behavior shown in the bottom panel. Aaron engaged in zero problem behaviors during the social-interaction and

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Insert Figure 2 here

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ignore conditions. He consistently engaged in higher levels of problem behavior in the noise condition (*M* = 9.7%, range = 6.4 – 12.9%). With respect to anxiety and avoidance behaviors, Aaron initially displayed anxiety and avoidance behaviors during the continuous social interaction (M = 1.6%; range = 0-20.0 %) and no-interaction (*M* = 8.0%, range = 0 – 16.7 %) conditions; however, a decreasing trend that approached zero was observed in both conditions. Comparatively, anxiety and avoidance behavior was consistently observed at increased levels (M = 91.1%; range = 83.3 - 96.7%) in the noise condition.

**Study 3: Preference Assessment of Coping Skills**

A preference assessment was conducted to identify which relaxation/coping skills Aaron would prefer to use when noise was present. After completion of the FA and the first three sessions of the treatment evaluation (see Study 4), Aaron received one-on-one training in (1) behavioral relaxation training (BRT; Poppen, 1998), (2) diaphragmatic deep breathing (Davis, Eshelman, & McKay, 2008), (3) looking at preferred pictures, (4) singing a preferred song, (5) drinking water, (6) asking for a "break" from the noise, (7) using a squeeze ball, and (8) asking for and using ear plugs.

Coping skill use was defined as actively using a trained relaxation strategy for 3s or longer. To achieve mastery of each skill, Aaron had to independently use the skill across three consecutive trials based upon specific criteria for each skill (training data and further descriptions of each skill are available on request).

*Procedure*

A multiple stimulus without replacement (MSWO; DeLeon & Iwata, 1996) was conducted to identify Aaron's preference for coping strategies after Aaron achieved mastery criterion across all coping skills, and before initial treatment sessions were initiated. The therapist presented a pictorial representation of Aaron engaging in a specific coping skill, and prompted him to choose one stimulus picture from the array that he liked most. After selecting, he was given positive praise (e.g., a 3-5s statement of positive praise) and allowed to engage in the coping skill for 30 s. Then, the chosen picture was removed and the trials resumed until all pictures were chosen, or until no choice was made within 5 minutes. This procedure was repeated for three series. Preference was determined by calculating the percentage of trials each picture was selected relative to the number of trials it was presented, and ranked from one (highest) to eight (lowest).

*Response Measurement and Reliability.* The primary therapist and an observer independently collected data during all three sessions with an IOA of 100%.

*Results*

The results of the coping skills MSWO are shown in Figure 3. Aaron demonstrated the strongest preference for asking for and using ear plugs, followed by singing a preferred song, behavior relaxation training, diaphragmatic deep breathing, and looking at positive pictures. Using a squeeze ball, drinking water, and giving himself a hug were chosen the least amount of times. The strongest preference outcomes were used to construct a pictorial list of his chosen coping skills that could be used to visually cue him during treatment sessions.

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Insert Figure 3 here

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## Study 4: Treatment Evaluation

### Treatment

As it was unlikely that Aaron would be able to terminate the aversive noises in a real-world environment, treatment was based on increasing tolerance to noise while allowing Aaron to engage in appropriate skills to help him relax or cope with his immediate environment and included systematic desensitization, extinction, and differential reinforcement of alternative behavior (DRA). To decrease the likelihood of anxiety/avoidant behavior and/or problem behavior from the outset of treatment, and ensure he could contact reinforcement contingences that were being implemented, during the initial treatment sessions the volume of noise was low (i.e., 45 dB) and was systematically increased.

*Procedure.* Treatment effects were evaluated via a multiple-baseline design across noises.

*Baseline.* During baseline, sessions were 2 min in duration to minimize exposure to noise and reduce the likelihood that extinction of target behavior might occur prior to treatment. A session began when the tape of the identified noise stimulus was started. The noise played at the terminal goal volume (i.e., 85 dB); escape extinction was implemented (i.e., target behaviors no longer terminated noise).

*Systematic desensitization/Stimulus Fading + Extinction + DRA.* Sessions were conducted as in baseline with a few exceptions. At the beginning of the treatment condition, noise volume was decreased to a level at which no target behavior was observed, and Aaron's HR averaged his normal resting HR (+/- 3 bpm); this corresponded to 45 dBs. Subsequently, noise volume was increased by 5 dB following two consecutive sessions during which no target behaviors were observed, and his HR was within +/- 3 bpm of his normal resting HR.

Prior to each session, to ensure Aaron was calm, two tactics were used. First, there was at least 15 minutes in-between each session to ensure appropriate behavioral de-escalation, minimize carryover effects, and allow his HR to return to his normal resting HR. Second, Aaron was given the opportunity to engage in a 10-minute BRT/Behavior Relaxation session prior to each treatment session. This relaxation technique has been shown to be highly effective for individuals with intellectual disability to elicit the relaxation response either as prevention on a noncontingent schedule or just prior to the onset of a stressful activity and has been associated with lower rates of physiological hyperarousal (Lindsay, Baty, Michie, & Richardson, 1989; Lindsay, Fee, Michie, & Heap, 1994; Morrison & Lindsay, 1997).

Throughout the session, Aaron earned praise and tokens for first choosing a specific coping skill, and then on a variable interval schedule of 30 s (VI 30) if he was actively using the coping skills. Once the session was over, Aaron could exchange his token(s) for access to a reward of his choice (i.e., either verbal report or picking from a pictorial representation of rewards from a list of choices).

*Generalization.* After Aaron reached the terminal goal of 85 dB, treatment probes were conducted in various locations first beginning in common areas of the clinic, then at his home, and finally in the community locations which had been identified by his mother as problematic to determine if Aaron could maintain treatment gains in more naturalistic conditions. Prior to generalization sessions, Aaron's coping skill picture list was shrunk and placed on a retractable keychain latched to a small pouch then secured on Aaron's waistband. The pouch his coping items of ear plugs and positive pictures. He received intensive training using/accessing these skills independently (without assistance from therapists before the initiation of generalization probes. During clinic and home generalization sessions, noise stimuli were presented at its terminal volume with treatment conditions in place. During community generalization sessions, the identified noise stimuli were not played and naturally occurring stimuli were used. Readings from a decibel meter indicated that noise levels ranged from 50 to 91 dB across community probes.

*Response Measurement and Reliability.* Occurrences of problem and phobic behaviors were recorded as described previously, and the same methods were used for calculating IOA across 47% of sessions; IOA averaged 94.7% (range, 90% to 100%). Reliability for sound level was assessed during 47% of the sessions and was always 100% agreement. During treatment sessions, IOA data was taken on use of coping/relation strategy and HR: IOA for coping/relaxation strategy use was M = 96.7% (range =93.5 – 100) and IOA for HR was 100%.

*Results*

Results from the treatment evaluation are depicted in Figure 4. . Readers may request raw heart rate data (prior to tabulating mean HR) by contacting the corresponding author. For the baby

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Insert Figure 4 about here

tantruming/crying noise stimuli during baseline conditions, elevated levels of total anxiety behavior (anxious + avoidance behaviors; average = 100%) were observed along with increased HR (*M* = 109.3bpm [range, 95 – 120 bpm]); total problem behaviors (i.e., self-injury + physical aggression) were observed to occur an average of 5.55% of intervals (range = 0 – 8.33%). Once treatment was initiated, Aaron's level of total anxiety and problem behaviors decreased to zero when the noise volume was decreased from 85 dB to 45 dB. He was also observed to begin using coping skills (percentage of use across intervals at 45 dB = 8.33% and 16.67%, respectively) despite having a HR which was not significantly elevated. As the noise volume was increased, his problem behavior remained relatively low and stable. Aaron was not observed to engage in any total anxiety behaviors until the noise volume level was approximately 70 dB. Aaron's data show a pattern began to emerge whereby at the first session of each new dB/volume level (except for 75 dB), an increase in total anxiety was observed followed by him not engaging in anxious behavior in subsequent sessions at that specific volume. A similar pattern was also observed with respect to Aaron's HR. That is, up until 70 dB Aaron's HR was not significantly different (+/- 3 bpm) compared to his normal resting HR, with an increase in HR (average bpm = 76.8) at 70 dB, 80dB, and 85dB, followed by a decrease. Aaron engaged in coping/relaxation skills at increasing rates (mean = 70.8% [range, 8.33 - 100%]) as the noise volume was increased. Generalization probes in the clinic and at home also yielded a high rate of coping skill use. Despite initial increases in total anxiety and HR during generalization probes, a gradual reduction of total anxiety and HR occurred.

Aaron began independently using coping skills (specifically singing a song and diaphragmatic deep breathing) he had learned during baseline conditions (i.e., the coping skill visual/picture symbol choices were not present nor were coping skill materials present) for the second noise stimuli of thunder at the highest volume level. As he began to use coping skills, a natural reduction in HR, problem behaviors, and total anxiety was observed to occur.

Results from the community generalization probes indicated Aaron continued to use his coping/relaxation skills at a high level (mean = 96.7% [range = 75.0 - 100%]) despite the unpredictability

of environmental noises. Problem behaviors remained low to near zero (range = 0-8.33%). Aaron's HR was initially elevated in the first generalization probe (76.9 = bpm), but averaged close to his regular resting HR (avg bpm = 72.5) for the remaining sessions. Similarly, Aaron was observed to engage in elevated levels of total anxiety behaviors in the first generalization probe (33.3%); however, a gradual decrease was noted across sessions, and stabilized at 0 across the last 6 generalization probes.

## Discussion

There is little existing literature regarding the treatment of anxiety in those with ASD and even less for persons diagnosed with ASD and co-occurring ID, despite significant comorbidity of these diagnoses. This case report demonstrates that utilizing modified systematic desensitization in combination with cognitive behavioral treatment was effective at reducing severe problem behavior, avoidance, and anxiety evoked by aversive noise in a teen diagnosed with ASD and co-occurring ID. Additionally, the methods and strategies we used focused on empowering an individual with ASD to implement one of a variety of treatment options to tolerate aversive stimuli in a more socially acceptable manner. There are several unique aspects to this case.

First, this patient engaged in severe problem behavior when encountering aversive stimuli that exists in many environments (noise) which limited his ability to participate in social settings. To best conceptualize treatment for Aaron, we made multiple modifications to assess his symptoms and distress level, including specific adaptations of systematic desensitization for his needs and abilities. Aaron has ASD and ID, which disadvantage him in multiple ways, including that he has deficits in emotional processing, communication, and cognitive domains. He also has co-occurring severe problem behaviors placing him at risk for harm to self and others. The pairing of behavioral indices of anxiety with a physiologic measure (i.e. HR) provided added, novel methods to best assess and track Aaron's progress despite his communication deficits, and is commensurate with prior attempts to measure anxiety in individuals with ID who engage in severe problem behavior (Jennett, Hagopian, & Beaulieu, 2011). The direct assessment of HR and overt anxiety behaviors, indirect assessments, and functional analysis allowed us to better understand Aaron's symptom presentation on multiple levels and across time.

Through using a multi-method assessment plan, the resulting treatment was best able to target the presenting symptoms and target problem behaviors, and best able to meet Aaron and his family's needs.

In order to best empower Aaron to have the greatest degree of self-determination , additional modifications occurred to facilitate his coping skill training, and choice and use of coping skills, as opposed to just reducing problem behavior. Often times, individuals who are likely to engage in problem behavior are subjected to more restrictive environments and/or stigmatizing or intensive interventions. However, our strategies exemplified person-centered planning (Carr et al., 2002) because we taught Aaron a variety of coping skill to use to tolerate noise without engaging in problem behavior, providing him with the agency to choose which intervention (coping skill) was most preferred by him at any given time. Many of the coping strategies used in this case could be implemented without any additional equipment (e.g., singing a preferred song, diaphragmatic deep breathing). It should be noted that despite Aaron choosing ear plugs as a coping skill, he was able to use these to only minimally attenuate the decibel level – enabling him to still experience the noise (as opposed to avoiding through the use of noise-cancelling headphones) but at a level that was more tolerable. Having low to no equipment for coping skill options was significant for multiple reasons. Aaron was able to use coping skills without relying on others, giving him more independence and ability to self-regulate; both are critical facets of self-determination. Finding ways to support opportunities for self-advocacy enables the individual to voice their opinions resulting in increased positive outcomes and addresses socially meaningful goals (Baer, Wolf, & Risley, 1968; Post, Pomery, Keirns, Cover, & Dorn, 2017). Additionally, the chosen coping strategies are reasonable to generalize to other settings or caregivers. Using a structured shaping and positive reinforcement paradigm, Aaron learned to independently use his coping skills to reduce anxiety and avoidance behaviors. He began using coping skills without the use of prompting, and generalized coping skill use to other noises (i.e., thunderstorms), caregivers, and in more naturalistic settings. The addition of generalization probes allowed Aaron to practice his coping skills in less controlled settings akin to those where the aversive stimuli are likely to randomly occur. Thus, it was clear that Aaron had learned that the coping skills were an effective way to reduce his anxiety and physiological discomfort

during aversive noise stimuli. Overall, this treatment better prepared Aaron to participate in a variety of social environments.

With the above modifications, desensitization was successful which is noteworthy in itself. Desensitization was demonstrated by his ability to endure previously intolerable, higher dB noises without an anxiety response (elevated HR, problem behaviors). Previous research with individuals with ASD has generally involved having the individual communicate for a break or using noise avoidance techniques (e.g., such as noise-cancelling headphones) to reduce problem behaviors (Ikuta et al., 2016; Severini et al., 2018). As it may not always be possible to avoid certain noises or take a break, desensitization may not only be practical but also more beneficial. Aaron's total problem and phobic avoidance behaviors were maintained by escape from noise (negative reinforcement) which is consistent with previous literature and emphasizes the importance of a goal of desensitization rather than avoidance. Further, avoidance and escape do not actually diminish the reoccurrence of anxiety over the long-term. The methods evaluated in this study could be combined with prior strategies from the literature to provide both active and passive methods for increasing tolerance of aversive noises, without increasing the likelihood of avoidance responses. That is, by building the response class repertoire for coping skills, it may allow for stimulus fading (e.g., of headphones) to occur more rapidly. Successful desensitization in this individual supports the potential efficacy of modified CBT as a treatment strategy for anxiety or problem behaviors in individuals with ASD and ID.

Although this case is encouraging, it is important to recognize its limitations. First, this is a case study and, given the inherent limitations of presenting one case, the individualized methodologies presented here may not generalize to others. Further given the needs of Aaron's case, it is unlikely that what we present here is representative of all persons with ASD who have problem behaviors evoked by noise hypersensitivity as well complex presentations more broadly. The comprehensive treatment consisted of multiple components that were all administered from the outset of treatment. However, the intricacies and modifications used may help other providers tailor treatments to fit the diverse needs of patient population that can vary widely. Further demonstration of case conceptualization and CBT

modification will help to broaden the clinician's toolbox when faced with challenging cases. Second, no long-term follow-up data are available for this case. While the results are initially promising, it is difficult to determine how Aaron will react to loud noises or other noise-based stressors in the future. Continuing to follow the individual more long-term could assist with determining the longevity and maintenance of treatment gains. Further, there may have been unexamined variables that could have influenced our data that were not accounted for including other sensory impairments (i.e., a sensory checklist was not included in our assessment), or presence of therapists or the list of coping skills serving as a discriminative stimulus in treatment sessions. However, Aaron did begin to use the less resource-dependent coping skills (i.e., diaphragmatic deep breathing, singing a song) during the thunderstorm baseline sessions when the pictorial list was unavailable; therefore, it appears that he did learn the utility of the skills and began using them even when other more salient discriminative stimuli (e.g.,. coping skill list, tangible coping skill items) were not present, Future studies should further examine variables that may influence treatment outcomes in this population. Despite these limitations, the outcomes of this case are informative and demonstrate how modifying best practices to fit specific, potentially complex presentations can lead to positive outcomes.

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## Figure Captions

*Figure 1. Outcomes of the Direct Observation of Anxiety (DOA): Noise Assessment*

*Figure 2. Outcomes of the Noise Functional Analysis*

*Figure 3. Outcomes of the Coping Skills Multiple Stimulus Without Replacement (MSWO) Preference Assessment*

*Figure 4. Treatment Evaluation: Systematic Desensitization/Stimulus Fading + Extinction + DRA*

Fig 1

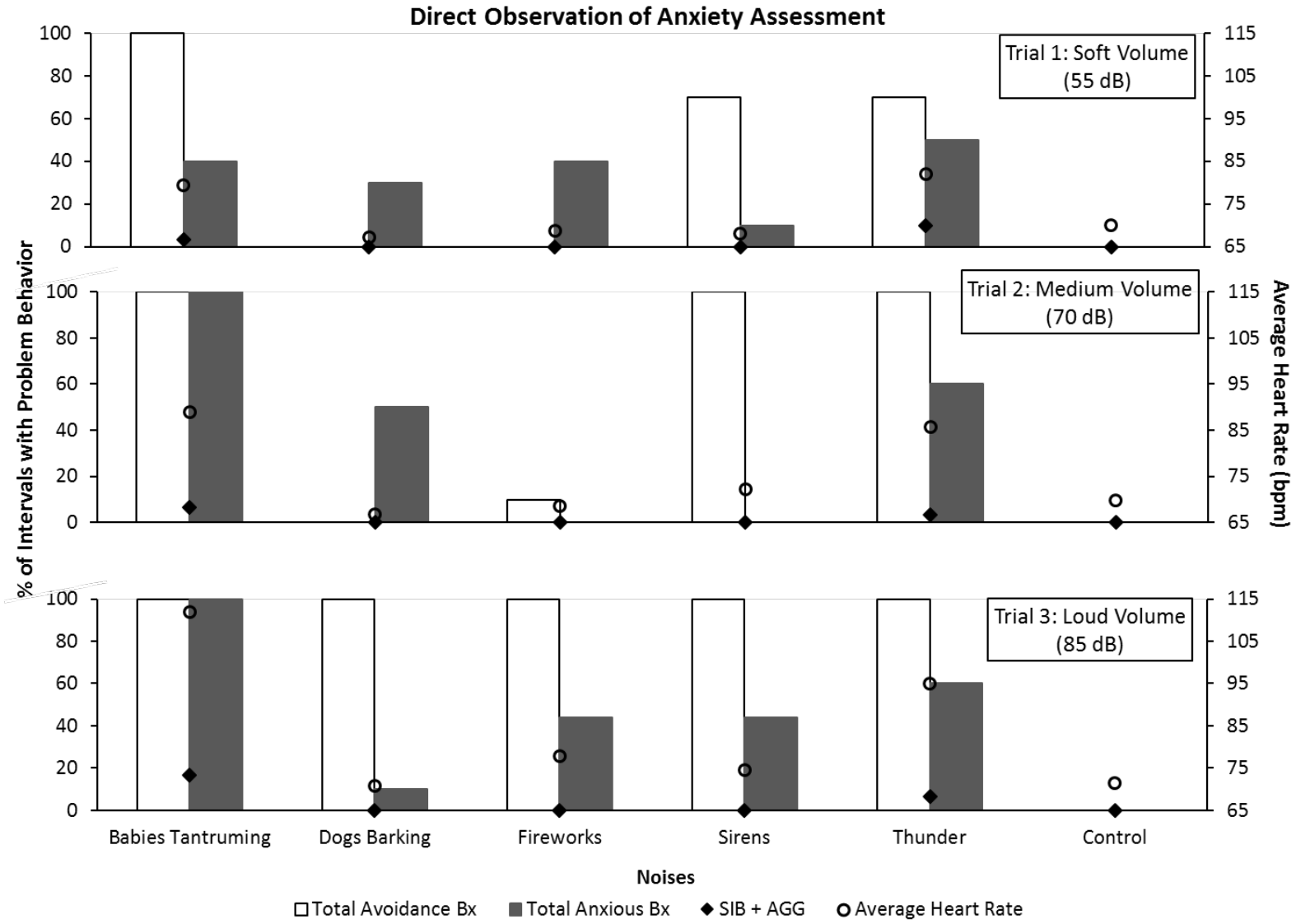

Direct Observation of Anxiety Assessment
Trial 1: Soft Volume (55 dB)
Trial 2: Medium Volume (70 dB)
Trial 3: Loud Volume (85 dB)
% of Intervals with Problem Behavior
Average Heart Rate (bpm)
0
20
40
60
80
100
65
75
85
95
105
115
Babies Tantruming
Dogs Barking
Fireworks
Sirens
Thunder
Control
Noises
Total Avoidance Bx
Total Anxious Bx
SIB + AGG
Average Heart Rate

Figure 2.

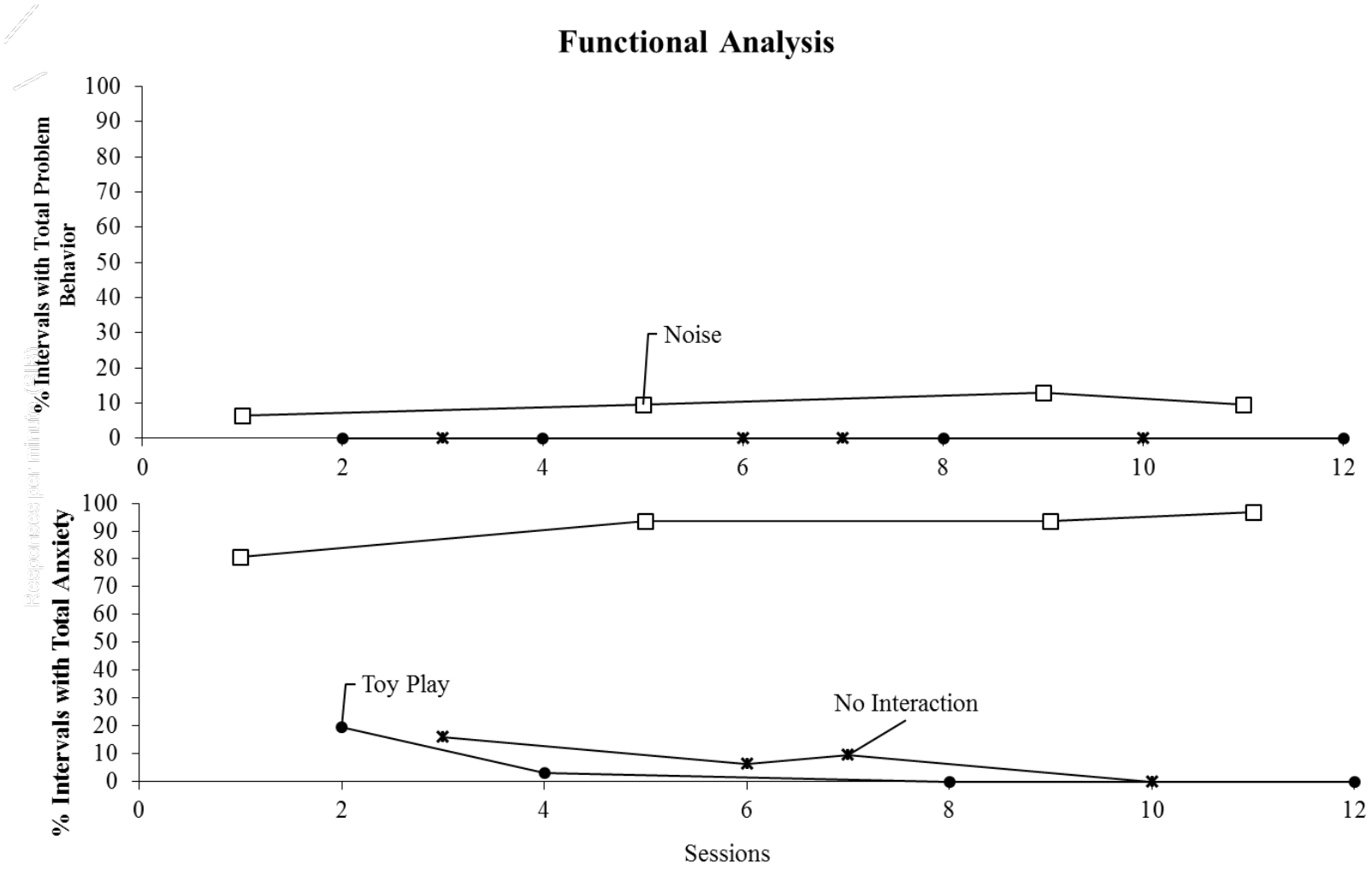
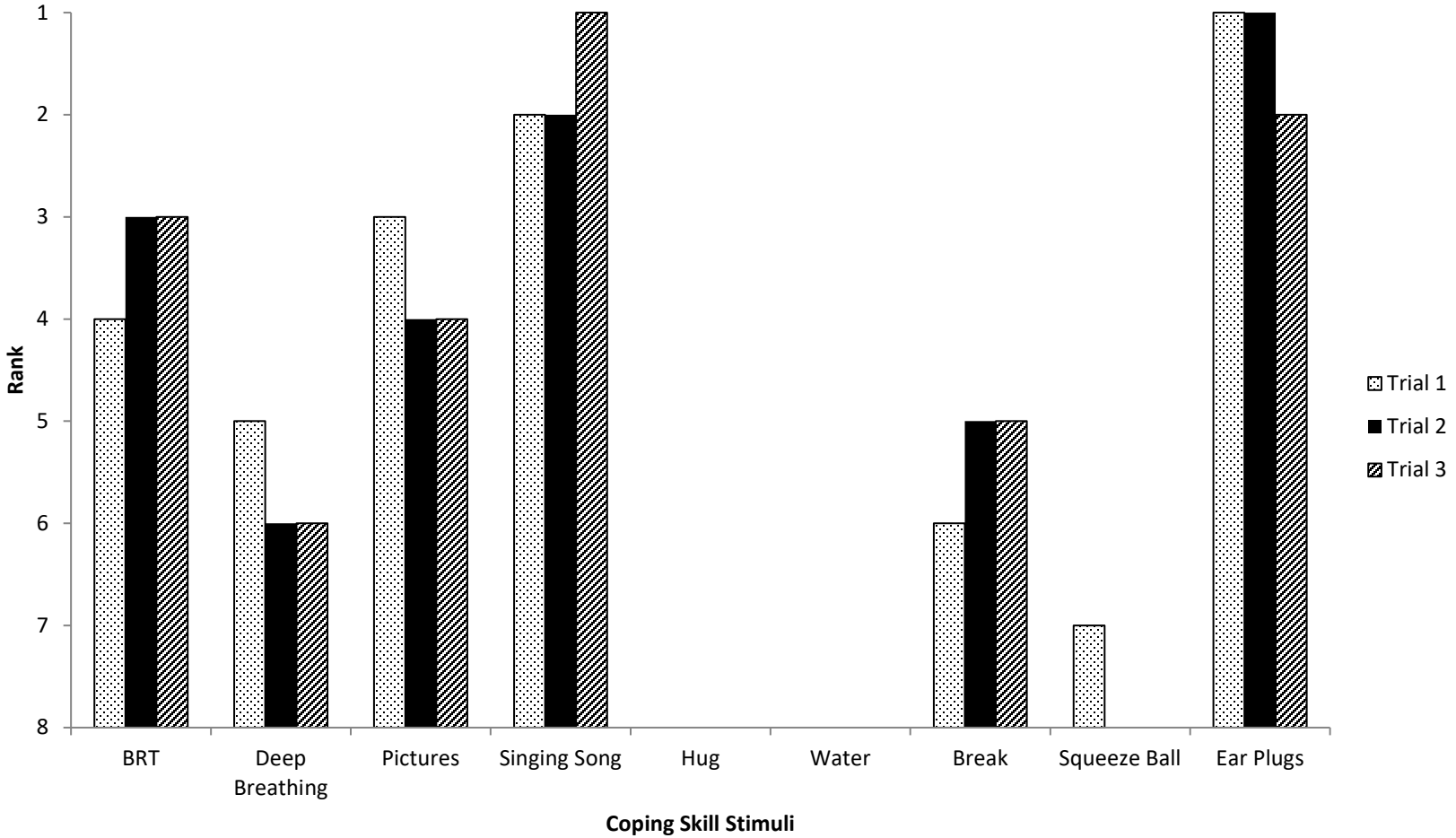
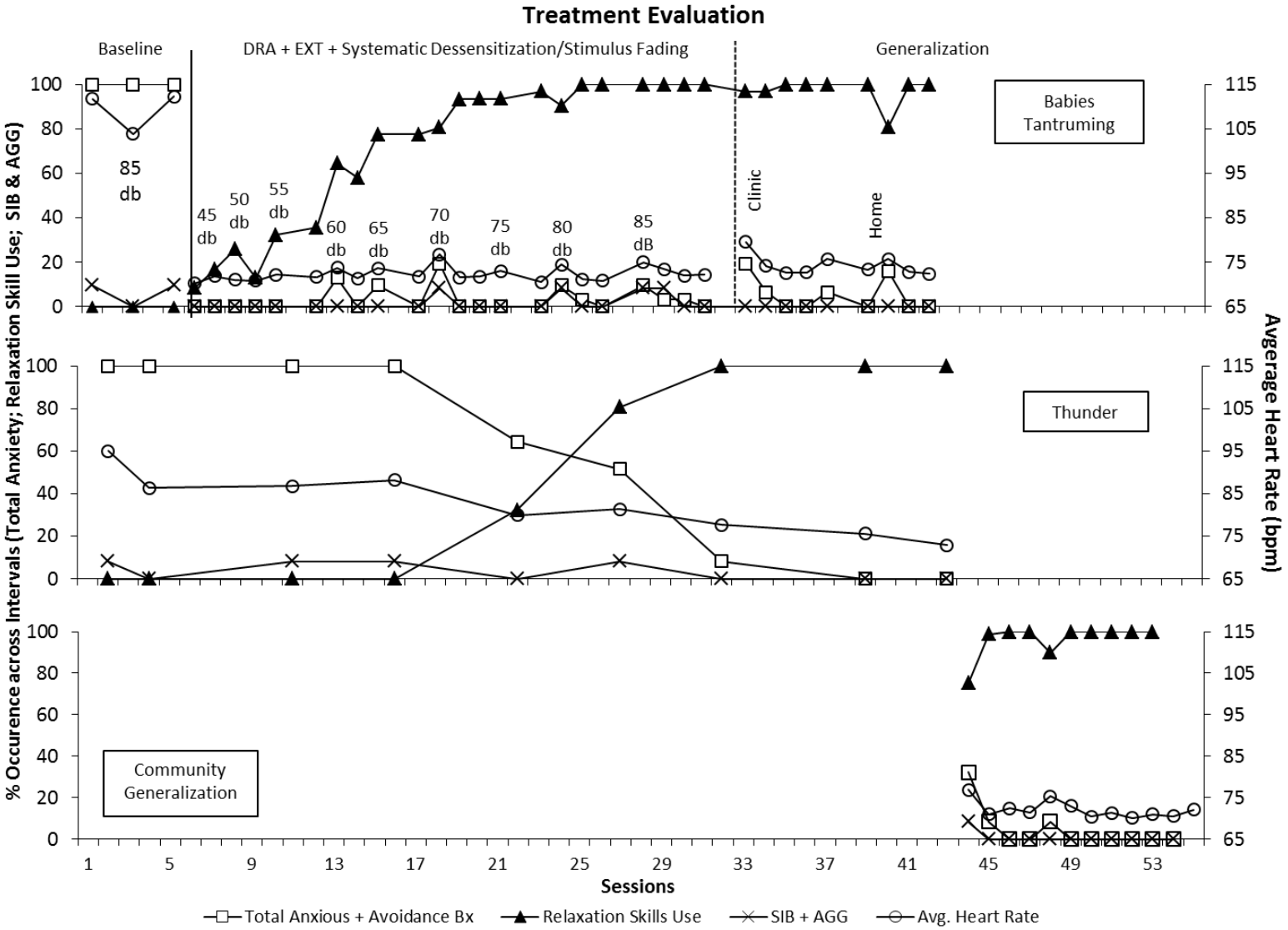

Functional Analysis
% Intervals with Total Problem Behavior
100
90
80
70
60
50
40
30
20
10
0
Noise
0
2
4
6
8
10
12
% Intervals with Total Anxiety
100
90
80
70
60
50
40
30
20
10
0
Toy Play
No Interaction
0
2
4
6
8
10
12
Sessions

Figure 3.




*Note:* The bars represent the rank (one [chosen first] to eight [chosen last/not chosen at all]) of each stimuli which are reflective of Aaron's choices.

Figure 4.


Treatment Evaluation
Baseline
DRA + EXT + Systematic Dessensitization/Stimulus Fading
Generalization
Babies Tantruming
Thunder
Community Generalization
85 db
45 db
50 db
55 db
60 db
65 db
70 db
75 db
80 db
85 dB
Clinic
Home
% Occurence across Intervals (Total Anxiety; Relaxation Skill Use; SIB & AGG)
Avgerage Heart Rate (bpm)
Sessions
Total Anxious + Avoidance Bx
Relaxation Skills Use
SIB + AGG
Avg. Heart Rate