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Sensory Desensitization Training for Successful Net Application and EEG/ERP Acquisition in Difficult to Test Children

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Abstract
This study examined the effectiveness of sensory desensitization training for 12 nonverbal children with autism to facilitate participation in an electrophysiological study assessing linguistic processing. Sensory desensitization was achieved for 10 of the 12 children and thus allowed collection of usable data in a passive linguistic paradigm. Application of such desensitization methods may be useful as a precursor to other assessment protocols for individuals who are difficult to test.

Keywords
ASD, EEG/ERPs, sensory desensitization, behavior modification, tactile reactivity, nonverbal

Introduction

Approximately one quarter of children diagnosed with an autism spectrum disorder (ASD) show no evidence of understanding oral language by traditional means of responding via looking, referencing, pointing, or following directions (Tager-Flusberg, Paul, & Lord, 2005). When individuals are nonverbal, and are unable to demonstrate evidence of language comprehension, it is difficult to know if they understand the task requirements and subsequently, they are characterized as *low functioning*. Electrophysiological methods (i.e., electroencephalogram [EEG] and computation of event-related potentials [ERPs]) have the capability to overcome the difficulties associated with assessing language processing because these techniques do not require an overt response from the individual. However, an essential requirement for an electrophysiological experiment is the ability to wear the EEG/ERP net for an extended period of time, with minimal body movement (Figure 1). The purpose of this study was to determine if a sensory desensitization training program would increase compliance for acquisition of clean, usable EEG/ERP data from a group of nonverbal/minimally verbal children with autism.

Tactile Sensitivity in Autism

Atypical responses to all types of sensory stimuli for individuals with ASD are reported in the literature (e.g., Baker, Lane, Angley, & Young, 2008; Baranek, Boyd, Poe, David, & Watson, 2007; Blakemore et al., 2006; Liss, Mailloux, & Erchull, 2008; Wiggins, Robins, Bakeman, & Adamson, 2009). For instance, Tomchek and Dunn (2007) found in a

Figure 1. EEG/ERP sensor net.
Note. EEG = electroencephalogram; ERP = event-related potential.

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Table 1. Participant Characteristics.

Participant	Age in years	Desensitization sessions	Mean tactile reactivity rating	Successfully trained	Usable ERP data
1	6	1	3	No	NA
2	7	2	2.5	No	NA
3	4	2	1	Yes	Yes
4	6	2	0.5	Yes	Yes
5	6	3	1.5	Yes	Yes
6	3	1	0.5	Yes	No
7	5	4	1	Yes	Yes
8	4	1	0.5	Yes	Yes
9	6	1	0.5	Yes	Yes
10	15	1	NA	Yes	Yes
11	5	1	NA	Yes	Yes
12	6	1	NA	Yes	Yes

Note. ERP = event-related potential; NA = not applicable.

group of 281 children with ASD, more than 60% reported tactile issues during grooming/hygiene tasks involving contact with the head and facial areas. These sensitivities are of particular concern for EEG/ERP procedures because successful data collection requires participants to wear the sensor net for an extended period of time, with sensors not only making contact with the head but also the face.

ERP Studies in Autism

Although a few studies have successfully acquired EEG/ERPs from nonverbal children with ASD (Dawson et al., 2002; Russo, Zecker, Trommer, Chen, & Kraus, 2009; Schmidt, Rey, Oram Cardy, & Roberts, 2009), there has been little documentation of the techniques involved in the successful net desensitization/application process that is paramount to collection of analyzable ERP data. Dawson et al. (2002) described a net desensitization/application technique used with young children with ASD, other developmental delays, and a control group. A maximum of seven training sessions were conducted to acclimate each child to the test setting and apparatus. Using this training technique, they successfully trained 71% of the children with ASD and acquired usable data from 76% of those children. In contrast to the present study, which includes a wider range of ages (i.e., 3–15 years of age), the Dawson et al. study included only 3- to 4-year olds. Moreover, our criterion for termination of training was more stringent (i.e., 10 min vs. 40 s, the Dawson study) and the present study describes the actual behavioral reinforcement techniques used.

The project described here examined factors that could best predict successful net application for a group of nonverbal/minimally verbal children with ASD, with the aim of tolerating placement of a 64-channel ERP sensor net for the duration of two linguistic EEG/ERP paradigms that passively assessed semantic and syntactic processing (i.e., at least 50 min).

Method

Participants

Children with a diagnosis of ASD who met the following criteria were included: (a) product of a full-term pregnancy, (b) no history of head trauma or other neurological conditions (e.g., seizures) or comorbid genetic conditions (e.g., Fragile X), (c) use fewer than five functional/intelligible words on a daily basis, and (d) English as the primary language spoken in the home. Twelve children with ASD ranging in age from 3 to 15 years (M = 6 years, 8 months, SD = 2.96; median = 6 years, 9 months, mode = 6 years, 9 months) participated in the desensitization training (see Table 1). According to parental report, all participants were involved in behavioral programs in their educational settings and all received speech/language therapy and occupational therapy. Participants were recruited via the International Autism Network (IAN) recruitment site and correspondence with schools in the metropolitan NY/NJ area that provide services for children with autism. All parents or caregivers gave written consent for their children to participate in the EEG/ERP study. The Institutional Review Boards of Rutgers University and City University of New York (CUNY) approved all study procedures.

Procedures

Prior to scheduling the ERP experiment with each participant, the parents completed a phone interview and written questionnaire, followed by desensitization training and lab orientation.

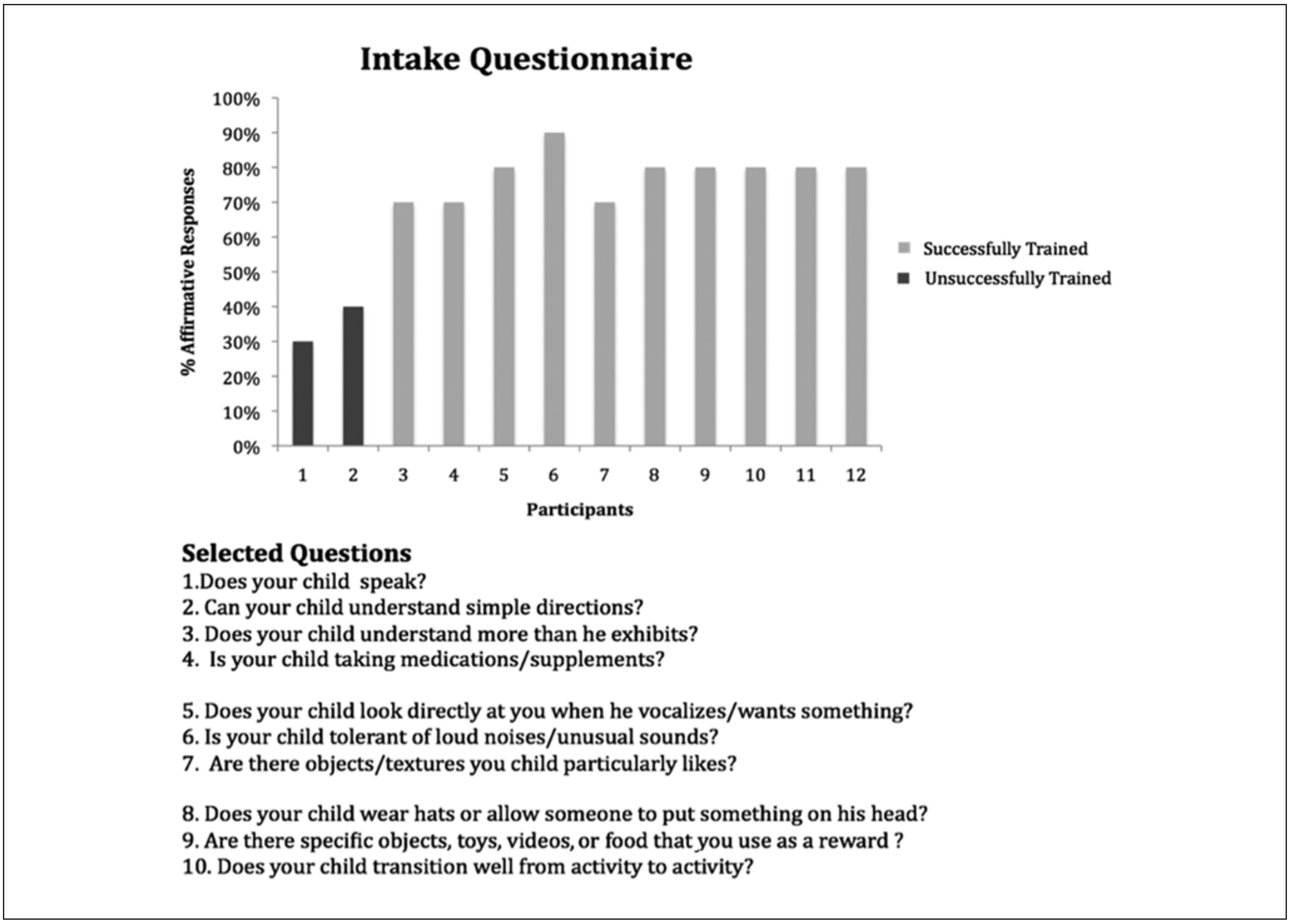

Figure 2. Affirmative responses on intake questionnaire.

Phone Interview and Written Questionnaire

An initial phone interview was conducted followed by completion of a detailed written questionnaire. Information gathered included developmental history, language comprehension/expression abilities, sensory characteristics, and intervention services including behavior modification programs, suggested materials to be used for optimal reinforcement during training (e.g., videos and food), as well as the ability to make transitions between activities and to different environmental settings, and the techniques used by parents to facilitate these transitions. Figure 2 contains a sample of questions from the intake questionnaire that were most relevant to the net application process.

Desensitization Training

To familiarize participants with the sensor net, children were seen either at home or in school prior to ERP testing. Each session lasted approximately 20 to 30 min. They were seated on a parent's lap or independently at a small table and chair/desk. Traditional behavior modification techniques involving shaping and positive reinforcement were used to gradually introduce the sensor net to the participant and encourage placement of the sensor net on his/her head. The researchers always approached the child from the front when placing the net near the child or on the head, to avoid frightening or surprising him/her.

The net training methods were never identical because of the unique behaviors of each child; however, the same general procedures were followed. Two experimenters were always present, one to apply the net and one to provide positive reinforcement. During the first visit, a *practice* sensor net (a net without attached wires) was introduced. The sensor net was dampened to soften the sponges and the child was encouraged to touch it. Then, either the parent and/or researcher put the net on themselves and encouraged the child to look and to touch it. The net was then placed in the child's lap and the reinforcement (usually a favorite DVD played on a portable DVD player) was introduced. From that point, the child was continually rewarded by access to the DVD as long as the net remained in contact with the child. If the child rejected the net, the cover of the DVD player was immediately closed. If food was the motivator, it was removed from sight. Based on the suggestions of each parent, a short key phrase or gesture (e.g., “Hat on,” “More Barney?”) was used to encourage the child to allow contact with the sensor net. As soon as the net was repositioned, the reinforcement was re-presented. The temporal relationship between the desired behavior (wearing/tolerating the net) and the reinforcement (video/food) was consistent during each training session, thereby making the contingency of touching/wearing the net clear to the participant. Gradually, the net was moved closer to the head via intermediate placements, such as the arm, back, or neck. Firm or light pressure varied depending upon the sensory needs of the child.

Subsequent sessions were identical; however, less time was spent in exploration and intermediate placements. Often the net could be placed directly onto the child’s head. Once the child was engaged in the reinforcement (e.g., video) and the net remained on top of the head, the researcher positioned the sensors in the appropriate scalp locations continuing to remove the reinforcement without comment if/when the child attempted to remove the net. When the net was properly placed and tolerated for at least 10 min while watching a favorite video on a portable DVD, the net application was deemed successful.

Lab Orientation

Social stories have been used successfully with children with ASD to help them understand the social and behavioral expectations of a situation and an environment (see Karkhaneh et al., 2010, for review). Thus, a modified version of a social story (Gray, 1994) was given to each family after the first net training session in the form of a *Welcome to the Lab* DVD that portrayed the entire experience in the lab from the perspective of a child. It included the physical environment of the building and lab, all the personnel that the child might see in the lab, and the net application in the ERP booth. The video was accompanied by child-friendly music but contained no dialogue. The family was encouraged to play the DVD several times for the child prior to the scheduled visit to the lab. Before the child entered the lab, all distracting stimuli were removed (e.g., books, pictures, jackets, etc.), computers in the common areas were turned off, all nonessential personnel were out of sight, and lights were dimmed in the ERP booth. The child and parent were immediately escorted into the ERP booth where a favorite video was on the screen or a favorite food/toy was visible. The child either sat on a parent’s lap or in a comfortable chair. In the booth, two researchers were present: one who applied the net and another researcher who served as the *entertainer* and engaged the child with the specific reinforcement, keeping his/her hands busy during net application. In each case, at least one of the researchers was familiar to the participant having been involved in the desensitization procedures. A favorite video was displayed on the experimental plasma screen and a similar contingency schedule of compliance and video watching was observed for net application. As soon as the researchers determined that the net was appropriately positioned, the EEG/ERP sensors were in good contact with the scalp and impedances were low, the experimental session began.

Experimental ERP Paradigm

A picture-word matching paradigm was used to assess the obligatory ERP components elicited by the visual presentation of pictures and associated auditory presentation of words and to assess lexical–semantic processing in nonverbal children with ASD and typically developing children. Pictures of animals or inanimate objects were presented on the computer monitor for 2,000 ms. A word that either matched or mismatched the object/animal in the picture was presented auditorily after a 500-ms delay, while the picture remained on the screen. A second word, either semantically associated or nonassociated with the first word, was presented auditorily 500 ms after the offset of the first word. Participants were asked to look at the pictures and listen to the words. No behavioral response was required. The continuous EEG was segmented into epochs and categorized as to the match or mismatch between picture and word; see Yu et al. (2012) for further details.

Data Analysis

A post hoc scale designed by the first author to assess tactile reactivity was developed as a means of addressing the severity of behavioral reactions exhibited by the children during the desensitization portion of the study. A global rating of tactile reactivity was given for each session after two research assistants who were trained by the first author independently reviewed the training tapes (Table 1). Scores ranged from 0 (no reactivity) to 3 (severe reactivity including crying, screaming, self-injurious behaviors, and attempting to leave the training session; see Table 2). Interrater agreement of 86% was achieved with raters reaching consensus on the sessions in question.

Results

Successful net application was achieved for 10 of the 12 children (83%) who were enrolled in the sensory desensitization training program; on average, each child required two training sessions (range = 1–4, $SD = 1.05$). Subsequently, analyzable EEG/ERP data were collected from 9 of the 10 children (90%) who achieved successful net application. One child’s data set was not usable due to excessive

Table 2. Tactile Reactivity Scale.

Rating	Description
0	No reactivity—calm, cooperative, does not react negatively when net is presented
1	Mild reactivity—cautious, looks tentatively at net, pulls away when net is presented but allows contact, pushes net away occasionally
2	Moderate reactivity—allows net near, then pulls away abruptly with contact, or pushes net away frequently, mild whining while net is in contact with body/head
3	Severe reactivity—crying/screaming when net is presented, won't allow net on or near body/head, self-injurious behavior exhibited, requests to leave room or gets up and moves away from training area

movement and pulling on the sensor net during presentation of the linguistic paradigm. For each trial, ERPs were time-locked to the onset of the picture and the onset of the first word to examine visual and auditory processing independently. A minimum of 20 artifact-free EEG segments was used in each condition for averaging ERPs (match condition, $M = 37$, $SD = 11.58$; mismatch condition, $M = 35.2$, $SD = 10.98$); please refer to Yu et al. (2012) for additional information and specific findings.

Tactile sensitivity about the head and face surfaced as the key predictor for success. This was noted in response to specific sensory questions during intake, ability to tolerate the net on the head for increasing amounts of time during training, as well as severity of reactions to tactile stimulation.

More specifically, three questions on the written questionnaire uniformly received negative responses from the parents of the children who we were unable to successfully train to wear the sensor net (see Figure 2). The children who were reported to have difficulty understanding simple directions; experienced extreme tactile sensitivity, particularly around the head and face; and had difficulty with transitions (i.e., #2, 8, 10) did not achieve successful ERP net application.

The mean duration of time the net was on the head for each session was 12 min (range = 7–16 min, $SD = 3.36$) for the children who successfully completed training. The children for whom training was unsuccessful tolerated the net placement for less than 2 min per session. Regarding the Tactile Reactivity Scale (see Table 2), the average rating for participants who achieved ERP net application was 1.0 ($SD = 0.4$) while the average for those who failed was 3.0 ($SD = 0.35$; see Table 1). Tactile reactivity decreased over time for the children who succeeded while the children who did not succeed continued to exhibit extreme levels of tactile reactivity, especially about the head and face.

Discussion

Successful sensory desensitization training to achieve the aim of tolerating placement of a 64-channel ERP sensor net for the duration of two linguistic EEG/ERP paradigms (i.e., at least 50 min) was the result of several key factors.

Behavior Modification

Abiding by classic behavior modification rules allowed the children to understand the relationship between the desired behavior (i.e., wearing the ERP net) and positive reinforcement.

Understanding the Sensory Characteristics and Interests of Individual Children

Our detailed intake procedures gathered information regarding each child's specific sensory characteristics. Fewer than 40% affirmative responses overall and negative responses to three questions in particular seemed to best predict those children who would not be successfully desensitized. The two children for whom net application was unsuccessful were reported to have significant hypersensitivity to touch, especially around the head and facial areas. This type of sensitivity could not be overcome after several training sessions and was so stressful for these children that we ended their sessions.

Interestingly, both children for whom training to wear the sensor net was not successful demonstrated understanding of the task based on incidental observations. For example, one participant approached the experimenter, placed the experimenter's hand on her head, and pointed to the DVD player. However, sensory defensiveness was so severe in both children that neither child was able to tolerate the net being placed on or near the head. Additional intake questions that specifically address tactile defensiveness in the head and face area might be helpful in choosing candidates who are more likely to experience success. Such inquiries might include the following: Does your child have a sensory processing disorder (mild, moderate, or severe)? Is your child fearful or bothered by getting a haircut? Is your child fearful or bothered by being hugged or kissed on the cheek? Is your child fearful or bothered by his face being dirty? (McIntosh, Miller, & Shyu, 1999; Schoen, Miller, & Green, 2008).

Creating an Individualized Plan for Desensitization

Before the children began net training, our research team had good knowledge of their temperaments, likes and dislikes, and behavioral characteristics, thus making each session individualized. Parents/caregivers were essential partners in the successful acquisition of EEG/ERP data. They supplied critical information regarding the most effective ways to work with their children. Parents were extremely helpful in suggesting optimal reinforcers, as well as using familiar verbal scripts to calm the children and keep them focused. In addition, they guided us regarding the need for intermediate placements of the sensor net before actual placement on the head. For example, one child simply complied when his mother said, “I’m going to put this on your head now!” Another child was compliant as long as the portable DVD player was playing her favorite DVD. Two other children were cooperative as long as their hands were kept busy with Play-Doh or snacks.

Creating an Individualized Plan for Transitioning From Reinforcement to Paradigm

Transitioning from one activity to another was an inherent problem with most children tested. One of the most difficult aspects of initiating the experimental session was the transition from the video reinforcement playing on the screen during net application to presentation of picture stimuli for the experimental paradigm. If necessary, a second reinforcement (often a preferred food or favorite object to hold) was introduced to facilitate the transition. Parents were extremely helpful in using familiar verbal scripts to calm the children, and to encourage and ensure them that the reinforcement (e.g., DVD) would return. Each paradigm was purposely broken down into short segments, so that the video reinforcement could be reintroduced as needed.

Practical Implications

Successful sensory desensitization training requires detailed input from the parents, awareness of an individual’s temperament and sensory characteristics, as well as a good understanding of behavior modification principles. Importantly, the desensitization training techniques we have described here may allow for collection of other types of test data from children who are nonverbal/minimally verbal and experience tactile reactivity. In addition, application of such desensitization techniques lend themselves for use in multiple settings, for example, as a precursor to other assessment protocols such as acquiring language or cognitive test information, from other difficult-to-test individuals (e.g., profound intellectual disability, attention deficit hyperactivity disorder, etc.) who respond to behavior modification programs in their daily lives.

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