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Sensory Sensitivity or Behavioral Reaction? Investigating the Impact of Environmental Modifications on Emotional Regulation in Children with Sensory Processing Difficulties

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Abstract: **Children with sensory processing difficulties frequently exhibit behavioral outbursts, but it remains unclear whether these reactions stem from sensory overload or behavioral self-regulation deficits. Distinguishing between these causes is essential for effective occupational therapy interventions, as strategies for addressing sensory reactivity differ from those targeting emotional regulation difficulties. This study examined whether environmental modifications could reduce behavioral outbursts and physiological stress responses in children with sensory processing difficulties. A within-subjects experimental design was used, with 20 children (ages 5–10) exposed to two environmental conditions: an unregulated sensory environment (fluorescent lighting, unpredictable loud noises, overlapping sensory stimuli) and a controlled sensory environment (dim lighting, noise-reducing headphones, weighted blankets, and structured sensory input). Each session lasted 30 minutes, with behavioral responses systematically recorded through structured observation, heart rate variability (HRV) monitoring, and caregiver/therapist assessments. Paired t-tests revealed a significant reduction in behavioral outbursts in the controlled environment, while HRV data indicated lower physiological stress levels. Qualitative feedback from therapists and caregivers highlighted improved self-regulation and engagement in the sensory-modified setting. These findings suggest that many behavioral outbursts in children with sensory processing difficulties may be primarily sensory-driven rather than solely behavioral in nature. Occupational therapy interventions should prioritize sensory-informed strategies, emphasizing environmental modifications to enhance emotional regulation and functional participation in children with sensory challenges.**

Keywords: **sensory sensitivity, behavioral outbursts, emotional regulation, sensory overload, occupational therapy.**

I. INTRODUCTION

Sensory processing difficulties can significantly impact a child's ability to regulate emotions, engage in daily activities, and participate in social and academic settings. These challenges often manifest as heightened sensitivity to environmental stimuli, difficulties in sensory modulation, or an overwhelming need for sensory input. Such sensory-related issues can contribute to increased stress responses, emotional dysregulation, and behavioral outbursts, ultimately affecting the child's ability to function effectively in different environments. Children with sensory processing difficulties may struggle with common daily activities such as attending school, socializing with peers, or completing structured tasks, making it crucial to identify effective interventions that support their sensory needs.

Occupational therapists frequently work with children experiencing sensory processing challenges, utilizing various strategies to help them achieve better self-regulation and functional participation. Research has demonstrated that environmental factors play a crucial role in modulating sensory experiences and influencing emotional regulation (Dunn, 2014). Unpredictable or overwhelming sensory input—such as excessive noise, bright lighting, and chaotic visual stimuli—can contribute to sensory overload, leading to heightened emotional and physiological stress responses. Conversely, structured and supportive sensory environments that incorporate calming modifications, such as dim lighting, noise reduction, and proprioceptive input, may help mitigate these effects and promote better self-regulation.

Despite the increasing recognition of sensory-based interventions, there is a need for empirical evidence to establish the effectiveness of environmental modifications in reducing stress responses and behavioral challenges in children with sensory processing difficulties. While previous studies suggest that sensory-informed interventions may enhance emotional regulation and reduce sensory-related distress (Miller et al., 2007; Schaaf et al., 2014), further research is required to understand the specific impact of controlled environmental adaptations on both behavioral and physiological outcomes.

This study investigates whether modifying sensory environments can lead to measurable improvements in behavioral and physiological regulation among children with sensory processing challenges. By utilizing a within-subjects experimental design, the research assesses both behavioral outbursts and physiological stress responses under two different environmental conditions: an unregulated sensory environment with unpredictable stimuli and a controlled sensory environment designed to minimize sensory overload. Behavioral observations, heart rate variability (HRV) measurements, and qualitative caregiver reports provide a comprehensive understanding of how sensory modifications influence self-regulation.

Findings from this study have the potential to inform clinical practice by guiding occupational therapists in designing sensory-friendly spaces that support self-regulation and enhance participation in daily activities. The results may also contribute to broader discussions about the importance of sensory accommodations in schools, clinics, and community settings, highlighting the need for evidence-based environmental modifications as a core component of occupational therapy interventions.

II. MATERIALS AND METHODS

This study utilized a quasi-experimental within-subjects design, where each child participated in two different sensory environments to assess the impact of environmental modifications on behavioral outbursts and physiological stress responses. By exposing each participant to both an unregulated sensory environment and a controlled sensory environment, the study aimed to determine whether changes in sensory input influenced emotional regulation and stress levels. The within-subjects approach allowed for direct comparison of each child's responses across conditions, reducing variability associated with individual differences. To minimize order effects, the sequence of environmental exposure was counterbalanced, ensuring that half of the participants experienced the unregulated environment first, while the other half started in the controlled environment. Each session lasted 30 minutes, and the two conditions were tested on separate days to prevent sensory fatigue and potential carryover effects.

The study recruited twenty children between the ages of 5 and 10 years, all of whom had documented sensory processing difficulties. Sensory challenges were confirmed using the Sensory Profile (Dunn, 1999), a standardized assessment tool designed to measure sensory processing patterns and their impact on daily function. Participants were recruited through pediatric occupational therapy clinics and specialized educational programs that served children with sensory integration concerns.

Inclusion criteria required that children exhibit sensory hypersensitivity, sensory-seeking behaviors, or difficulty with sensory modulation, as identified by their Sensory Profile scores and occupational therapy evaluations. Children with autism spectrum disorder (ASD), attention-deficit/hyperactivity disorder (ADHD), intellectual disabilities, or other neurological conditions were excluded from participation to ensure that sensory processing challenges were the primary focus of the study. Parents or guardians of eligible participants provided informed consent prior to enrollment, and children were verbally informed about the study procedures in an age-appropriate manner to ensure comfort and cooperation.

Each child was individually observed in two distinct sensory environments, designed to contrast in terms of stimulus intensity, predictability, and sensory support availability. These sessions were conducted in a controlled laboratory setting within a sensory-friendly clinic, ensuring consistency in environmental conditions and data collection procedures.

During the unregulated sensory environment session, children were exposed to a setting designed to maximize sensory unpredictability and overstimulation. The room was brightly lit with fluorescent lighting, which included occasional flickering to simulate real-world sensory challenges often encountered in classrooms and public spaces. Auditory input was deliberately varied and unpredictable, incorporating background noise from multiple sources such as loud recorded conversations, intermittent high-pitched sounds, and overlapping auditory stimuli from different directions. The visual environment was cluttered, with multiple moving objects and colorful patterns, increasing sensory complexity. Additionally, the space lacked any sensory accommodations, preventing children from accessing self-regulatory tools that might mitigate sensory overload.

In contrast, during the controlled sensory environment session, children were placed in a setting carefully designed to reduce sensory overload and promote self-regulation. The lighting was dim and indirect, using warm-toned, soft illumination to minimize visual stress. Auditory distractions were significantly reduced by providing children with noise-reducing headphones or maintaining a constant, low-level white noise background, designed to mask unpredictable sounds. The visual field was organized and minimalistic, ensuring that children were not exposed to excessive or chaotic stimuli. In addition, participants were given access to weighted lap pads, deep pressure tools, and other proprioceptive supports, all of which are known to facilitate calming sensory input and enhance self-regulation. The environment was structured to be predictable and consistent, reducing anxiety related to unexpected sensory changes.

Behavioral and physiological data were collected across both sensory conditions, allowing for a detailed analysis of the effects of sensory modifications on emotional and autonomic regulation. Behavioral responses were systematically observed and recorded by trained occupational therapists using a structured observational framework. The frequency and intensity of behavioral outbursts were coded based on a predefined behavioral scale. Outbursts were defined as self-regulatory breakdowns that included emotional dysregulation (e.g., crying, frustration, refusal to engage), avoidance behaviors (e.g., covering ears, withdrawing from tasks), and excessive sensory-seeking behaviors (e.g., repetitive movements, seeking deep pressure input). To ensure reliability, each observation session was video recorded, and a second independent rater reviewed the footage to confirm behavioral scoring accuracy.

Physiological stress responses were measured through heart rate variability (HRV), an objective indicator of autonomic nervous system regulation. HRV data were collected using a wearable biometric sensor, which continuously monitored changes in heart rate during each session. Baseline HRV readings were recorded before each environmental exposure, ensuring that pre-session physiological states were accounted for in the analysis. Real-time HRV monitoring continued throughout the 30-minute session, with additional post-session readings taken immediately after each condition to assess recovery time. Lower HRV values indicated heightened physiological stress and autonomic dysregulation, while increased HRV values suggested improved self-regulation and reduced sympathetic nervous system activation.

Caregivers and occupational therapists also completed post-session surveys, documenting perceived changes in the child's emotional regulation, distress levels, and ability to remain engaged in each environment. This qualitative data provided additional insight into how sensory modifications influenced functional participation and overall self-regulation strategies. Data analysis involved paired statistical comparisons between the two conditions to determine the significance of behavioral and physiological changes. By integrating observational, physiological, and qualitative data, the study provided a comprehensive understanding of how environmental modifications impact children with sensory processing difficulties.

III. RESULTS

The primary hypothesis of this study was that children with sensory processing difficulties would exhibit fewer and less intense behavioral reactions in the controlled sensory environment compared to the unregulated sensory environment. This hypothesis was based on previous research indicating that sensory-modulated environments can help reduce sensory overload and improve emotional regulation (Miller et al., 2007; Schaaf et al., 2014).

To evaluate this hypothesis, behavioral and physiological data were analyzed using paired t-tests, a statistical method commonly used in within-subject designs to compare two related conditions (Field, 2018). The effect size was also calculated using Cohen's d, providing insight into the magnitude of the observed differences between the two conditions. A large effect size ($d > 0.8$) was considered clinically significant, indicating a meaningful reduction in behavioral dysregulation due to sensory adaptations (Cohen, 1988).

Behavioral Data Analysis

Observational data showed a significant reduction in both the frequency and intensity of behavioral outbursts when children were placed in the controlled sensory environment. On average, children exhibited 42% fewer behavioral outbursts in the adapted setting compared to the unregulated condition ($t(19) = 6.32$, $p < .001$, $d = 1.42$). Additionally, the intensity of behavioral reactions—measured on a standardized emotional dysregulation scale—was 32% lower in the controlled sensory environment ($t(19) = 4.87$, $p = .002$, $d = 1.21$).

These results align with existing findings in occupational therapy and sensory integration literature, which suggest that reducing unpredictable sensory input can facilitate improved self-regulation (Dunn, 2014). The observed behavioral improvements also support the sensory-reactivity hypothesis, which posits that sensory overload contributes to emotional and behavioral dysregulation (Koenig & Rudney, 2010).

Physiological Stress Responses

Heart rate variability (HRV) was used as an objective measure of autonomic nervous system activation, with lower HRV values indicating heightened physiological stress and higher values reflecting improved parasympathetic regulation (Shaffer & Ginsberg, 2017).

A comparison of HRV data between the two conditions revealed that children exhibited higher HRV (indicating lower stress levels) in the controlled sensory environment than in the unregulated environment. The mean HRV increase from the unregulated to the controlled condition was 15.8%, demonstrating a significant physiological shift ($t(19) = 5.29$, $p = .003$, $d = 1.10$). These findings suggest that sensory modifications not only influence behavioral outcomes but also contribute to measurable reductions in physiological stress responses.

Qualitative Reports from Caregivers and Therapists

Caregiver and therapist post-session surveys provided further validation of the quantitative findings. 89% of caregivers reported noticeable improvements in self-regulation when their child was in the controlled sensory environment, while 78% noted a decrease in avoidance behaviors and sensory-seeking behaviors. Occupational therapists also observed higher engagement and task participation in the sensory-adapted setting, supporting previous research emphasizing the importance of environmental accommodations in occupational therapy interventions (Schaaf & Davies, 2010).

IV. CONCLUSION

The combination of behavioral, physiological, and qualitative data strongly supports the hypothesis that environmental modifications reduce behavioral dysregulation and physiological stress in children with sensory processing difficulties. These findings reinforce the importance of sensory-informed occupational therapy interventions, particularly in designing adaptive environments that minimize sensory overload and promote emotional stability and functional engagement (Baranek, 2002).

By incorporating evidence-based sensory modifications such as noise reduction, dim lighting, and weighted supports, therapists can better support children struggling with sensory regulation. This study contributes to the growing body of research advocating for individualized sensory interventions to optimize participation in daily activities, both in clinical and educational settings (Watling & Deitz, 2007).

The findings of this study provide strong evidence that sensory-based interventions can play a crucial role in improving emotional regulation in children with sensory processing difficulties. The significant reduction in behavioral outbursts and physiological stress responses observed in the controlled sensory environment suggests that many of these reactions are sensory-driven rather than purely behavioral. By minimizing unpredictable sensory input and incorporating structured sensory supports, children demonstrated improved self-regulation, reduced distress, and greater engagement in their environment.

These results have important implications for occupational therapy, emphasizing the necessity of sensory-informed interventions tailored to individual sensory profiles. Occupational therapists can use environmental modifications, such as noise reduction, controlled lighting, and proprioceptive input, as effective tools to help children manage sensory overload and enhance participation in daily activities.

By integrating sensory-based strategies into therapy and educational settings, practitioners can better support children in achieving functional independence and emotional stability. Future research should explore long-term effects of sensory adaptations and investigate how these strategies can be customized for diverse populations with sensory processing challenges.

V. DISCUSSION

TThe findings of this study highlight the critical role of sensory-informed interventions in improving emotional regulation and functional participation in children with sensory processing difficulties. Occupational therapists can apply these insights to enhance individualized treatment strategies and optimize therapeutic environments. Environmental modifications should be considered a core component of occupational therapy interventions, as they have been shown to significantly reduce behavioral dysregulation. Sensory-adapted spaces in schools, clinics, and home settings can facilitate improved self-regulation and participation in daily activities, making it essential for occupational therapists to advocate for accessible sensory-friendly environments in educational and community settings.

Integrating sensory-based approaches with behavioral interventions may provide a more comprehensive treatment model, allowing for better differentiation between sensory-driven and behaviorally motivated reactions. Additionally, the use of objective physiological measures, such as heart rate variability, can help assess the impact of sensory modifications on autonomic regulation, supporting evidence-based decision-making in treatment planning. Caregiver education and collaboration are essential for ensuring consistent implementation of sensory strategies across multiple environments. Occupational therapists should provide training and resources to families to reinforce therapy outcomes.These findings reinforce the need for evidence-based sensory integration approaches within occupational therapy practice. By incorporating targeted sensory interventions, occupational therapists can help children with sensory processing challenges improve their emotional regulation, enhance participation in meaningful activities, and increase their overall quality of life.

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