

Perceiving Through Colors: Visual Supports for Children With Autism

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ABSTRACT

Visual supports are a communication tool for children with autism spectrum disorder (ASD) to expand their interaction with their surroundings. Interventions to assist children with autism include visual resources as cognitive methods to help them understand concepts, communicate needs, and better navigate their world. One of the key elements in effective visual interaction with an essential effect on autistic children's behavior is color. Prior studies demonstrated that various colors have different impacts on children with autism. Responses to color are both physiological and psychological. Children with ASD may show unusual sensory processing and perception, as observed by anecdotal evidence from persons with autism and their parents, caregivers, and teachers, suggesting that autistic children may perceive colors differently compared to neurotypical children. Colors' effect on ASD children may extend well beyond what we imagine. We should not neglect the importance of the particular color effect to avoid sensory overload and attain an optimal setting for children with ASD. Our research tries to further investigate and highlight the relationship between autism and colors by decoding the need of autistic children as follows: (i) whether the color perception is atypical in these children, (ii) highlighting autism-friendly colors, (iii) underlining what colors can improve ASD children's interaction skills and attention span in different settings. This need-finding study extracted from the existing research and the feedback of users and clinical professionals to identify categories of needs and in-depth observations to understand those categories. Based on our literature review, anecdotal, and observational methods, the results emphasize the need for (i) an in-depth investigation of the physiological and psychological color's effect; (ii) efficient and reliable tracking methods for unbiased, passive data collection considering challenges associated with the extensive and often unknown interaction characteristics of each autism spectrum; (iii) thorough data analysis and hidden pattern discovery of the collected high-dimensional data; and (iv) adaptive and customizable technology-based guidelines for parents, caregivers, teachers of autistic children, and persons with autism themselves.

Keywords: Autism, Visual support, Color, Need finding

INTRODUCTION

Autism Spectrum Disorder (ASD) is a lifelong, complicated developmental disorder that impairs the individual's ability to communicate, interact, and process information. "Autism belongs to heterogeneous categories of developmental disabilities where neurological disorders lead to deficits in a child's ability to communicate, understand language, play, develop social skills, and

relate to others” (Rao and Gagie, 2006, p. 26). These deficits’ severity also can vary, which is why the disability is identified as a spectrum. Autism affects how one perceives the world and interacts with others – they see, hear, and feel differently (NHS England, 2017). Research indicates that early interventions are more likely to have significant long-term positive effects on ASD symptoms and support the development and well-being of an autistic child, to cope with the disability (National Research Council et al., 2001; Helt et al., 2008; Corsello, 2005; NIH, 2021).

Visual Support

Visual supports are a communication tool for children with autism to extend their interaction with their surroundings. Interventions to aid these children contain visual resources as cognitive methods to help them understand concepts, communicate needs, and better navigate their world (Hayes et al., 2010; Lexington, 2021). Practical strategies to use visual supports such as tangible objects, pictures, symbols, printed words, images, “objects in the environment, arrangement of the environment or visual boundaries, maps, schedules, labels, organization systems, timelines, and scripts” are all part of supportive interventions for autistic children (National Research Council et al., 2001). These supports are utilized across different settings to assist individuals with ASD in maintaining attention and reducing the symptoms associated with cognitive, communication, and social disabilities (Hodgdon, 1995; National Research Council et al., 2001).

For instance, the picture exchange communication system (PECS) was initially designed to enable young children with autism who lack functional communication to initiate requests, describe what they observed, and communicate without dependence on speech (Sulzer-Azaroff et al., 2009). Autistic children use cards with symbols, pictures, printed words, or photographs to ask, comment, or answer questions. “Findings suggest that PECS provides people around the globe with no or impaired speech with a functional means of interaction and communication” (Sulzer-Azaroff et al., 2009).

Color

Color and color-coding are powerful visual interaction features that produce profound psychological and physiological reactions with an essential effect on a wide range of abilities for which visual supports can facilitate development, including attention, motivation, and behavioral skills (Gaines and Curry, 2011; Hume, 2008). ASD children with heightened sensory responses and strong visual processing abilities may perceive color differently and show unusual sensory processing compared to neurotypical children, as observed by anecdotal evidence from persons with autism and their parents, caregivers, and teachers (Franklin et al., 2008; Freed and Parsons, 1998c). For instance, Charlotte Moore, a mother of three children, two of whom have autism, described her son’s sensitivity and obsession with color in her book: (Franklin et al., 2008; Moore, 2007).

“By and large, he would eat only red food, and to this day, he uses ketchup to mask unwelcome colors. I call his color obsession “mild” because I’ve heard of far more extreme cases. George always retained some measure of flexibility.”

- Charlotte Moore

To date, little is understood about the relationship between autism and color. There has not been much experimental research on whether autism is associated with unusual color perception and cognition, despite the prevalence of anecdotal evidence suggesting this (Franklin et al., 2008). Herein, we describe whether the color perception is typical in these children to highlight autism-friendly colors and how they can improve ASD children’s interaction skills and attention span in various settings. The implications of colors on autistic children must be understood to utilize colors as visual support (Lexington, 2021).

Color Effect

“Autistics perceive their surrounding not only as overwhelmingly intense due to the hyper-reactivity of primary sensory areas but also as aversive and highly stressful due to an overly reactive amygdala, which makes quick and powerful fear associations with usually neutral stimuli” (Markram and Markram, 2010). Limited pioneering findings suggest that the primary mechanism underlying perceptual categorization of colors may not vary between children with ASD and the ones without. However, the increased sensitivity to sensory stimulation would influence color perception exhibited by children with autism, resulting in an aversion to some specific colors that are often favored by neurotypical children (Grandgeorge and Masataka, 2016). It is evident that children with autism view the world differently than children with typical development. Therefore, it’s essential to understand how colors impact them in order to apply color effectively. We advise paying close attention to the significance of the particular color effect to minimize sensory overload and create the optimal environment for children with ASD.

Need-Finding

This study investigates the relationship between autism and colors by decoding the needs of autistic children. The challenge of such a study is deeply connected with autistic children’s behavior/emotions and their hesitation to interact. As such, a need-finding approach helps investigate autistic children with internalizing (e.g., social dysfunction, depression, anxiety, cognitive problems, and avoidance symptoms) and externalizing behaviors (e.g., impaired concentration, hyperactivity, aggression, and behavioral disorders) (Ding et al., 2021). Need-finding is a non-linear, human-centered design approach to understanding individuals’ unmet needs and uncovering their latent challenges (Schaffhausen and Kowalewski, 2015; Patnaik and Becker, 2010). This need-finding study extracted from the existing research and the feedback of users and clinical professionals to identify categories of needs for in-depth observations to understand such categories’ challenges.

METHOD

Collect: To find related categories, preliminary literature research was conducted using particular keywords. Then, by employing this method, it was feasible to identify more exact terminologies related to color theory and its effects on physiology and psychology. Autism, color, visual support, learning disabilities, and attention deficit disorder were the original essential terms. Then secondary ones – special education, the learning environment, observational data gathering, and anecdotal evidence – were included. The utilized databases were EBSCO, Health Source, NDAR, PsycInfo, PsycArticles, Psychology, and Behavioral Sciences Collection, ScienceDirect, Google Scholar, PubMed, ScienceDirect, JSTOR, and Medline. *Categorize:* relevant studies were chosen from the review of the articles, books, and references. The research was then categorized into three groups based on themes of visual support; color and color theory; as well as a physiological and psychological correlation with color. *Curate:* based on how they relate to both autistic and typical children, the three categories were selected to curate the knowledge-based foundation. *Correlate:* the curated data were compared and correlated with anecdotal evidence and observational data taken from evidence-based platforms like ‘The Mighty,’ an online community for people interested in health to exchange stories and “Get the health answers from people who live it every day.” (The Mighty. Making health about people., 2014). *Customize:* finally, after evaluating the available findings, four needs that satisfied the original objectives were found.

COLOR AND AUTISM RELATIONSHIP NEEDS

Based on our literature review, anecdotal, survey, and observational methods, we developed a series of common categories of needs, including (i) an in-depth investigation of the physiological and psychological color’s effect; (ii) efficient and reliable tracking methods for unbiased, passive data collection considering challenges associated with the extensive and often unknown interaction characteristics of each autism spectrum; (iii) thorough data analysis and hidden pattern discovery of the collected high-dimensional data; and (iv) adaptive and customizable technology-based guidelines for parents, caregivers, teachers of autistic children, and persons with autism themselves. These findings provide a comprehensive understanding of colors’ effect on ASD children and the existing gaps that may extend well beyond what we could imagine.

In-Depth Analysis of Physiological and Psychological Color’s Effect

Color is a physical property of surfaces, objects, and places, plus a perception rendered by the light identified visually and processed by the brain. It is a reaction of the brain to the visual stimuli received. Color and light are primary factors of impact in any setting. Their collective effect maintains notable significance regarding psychological and physiological reactions (National Institutes of Health (NIH), 2020). Studies of children’s color preferences have a long history as a practical design element that triggers profound psychological and physiological reactions in the general population. These findings

have demonstrated a solid relationship between color preferences, emotions, and children's performance (Gaines and Curry, 2011).

Responses to color are physiological (physical), psychological (emotional), and distinctive based on color attributes and physical anomalies (Gaines and Curry, 2011). Concerning autistic children with neurodevelopmental disorders and unusual sensory processing, significant challenges may emerge due to color's profound physical and mental effects related to both color's nature and ASD characteristics (Grandgeorge and Masataka, 2016). Each color has three dimensions: hue, value, and intensity. Hue is the name of a color like red, blue, or yellow. Value is the degree of darkness or lightness of a color, and the addition of black or white can alter it. Intensity or saturation refers to the purity of a color, often measured by boldness or dullness (Franklin et al., 2008). Children with autism spectrum disorder experience a more extreme version of the world than other children. "For more than 90%, sounds are louder, colors are brighter, and touch can be a disturbing intrusion. The reason may be that many autistic people also have synesthesia, a condition of intertwined perception in which one sense stimulates another" (American Association for the Advancement of Science - AAAS, 2013).

However, few studies have focused on color preference in children with autism and whether color perception is typical in these children. Similarly, not enough direct experimental investigations have investigated autism-friendly colors and their impact on autistic children's interaction skills and attention span in various settings (Grandgeorge and Masataka, 2016). In addition, investigations conducted on the effects of physiological and psychological color on ASD are limited; consequently, sufficient evidence does not exist to support their degree of effectiveness in this respect. Exploration of color perception and theory is necessary for understanding the physiological and psychological responses to colors considering the biological, emotional, and behavioral characteristics of autistic children.

To meet these needs, we plan to create an interactive digital research repository to foster the exchange and development of knowledge/information and evidence-based observations. Therefore, tracing, classifying, simplifying, and visualizing the chain of research and observations from related disciplines – physiology, psychology, behavioral study, education, and design, to name a few – and their interconnectivity is much needed.

Reliable, Unbiased, Passive Data Collection

Unfortunately, supports are not always in place to ensure that the needs of autistic children are being met appropriately, partly due to the challenges related to observational studies and experiments. Assessment of effective interventions to assist autistic children, including visual resources as cognitive methods, depends primarily on studies that analyze data abstracted from literature studies, medical records, or collected prospectively for research purposes rather than controlled by the researchers. Biases associated with observational studies are significantly influenced by study design, data collection methods, statistical analysis, and the characteristics of autistic children (Hartz and Marsh, 2003). Errors in ASD observational studies that cause

an invalid study are often deeply connected with autistic children's behavior/emotions/interaction due to their internalizing (e.g., social dysfunction, cognitive problems, anxiety, depression, and avoidance symptoms) and externalizing behaviors (e.g., impaired concentration, hyperactivity, aggression, and behavioral disorders) (Ding et al., 2021).

Researchers should know the initiatives needed to collect unbiased datasets and understand behaviors to create hypotheses and intervention strategies. For instance, the continuous and discontinuous applied behavior analysis (ABA) strategy uses applied behavior analysis to allow providers to understand behaviors and patterns over a long or short period (Harris and Delmolino, 2002).

There is an obvious need for additional research to establish distinct criteria and determine the most effective techniques for gathering data from autistic children and focusing on their symptom correlation with various phenomena like the color (Mucchetti, 2013). The suggested approach should integrate techniques aimed at such issues to eliminate errors and biases, improve data quality, and obtain more accuracy from the analysis. This strategy would reduce uncertainty in data interpretation while addressing inherent behavioral challenges.

High-Dimensional Data Analysis and Hidden Pattern Discovery

By understanding the details of such data collection and its needs, inconsistencies between various findings should be recognized, and appropriate analyzing methods should reduce biases, misunderstandings, and barriers. However, reviewing the current literature, collecting anecdotal information, conducting observational studies, and comparing the results with controlled investigations to identify the most intriguing data dimensions are challenging. It is essential to deal with complex, interrelated behavioral datasets, such as autism datasets, to rapidly sort through a mountain of informational and observational data to identify the collection's primary predictive, descriptive, and explanatory features. Such issues should be addressed by the processes used in integrative data collection. To uncover any correlation or causation between autism and colors, we will then use machine learning and neural network classification approaches.

Interactive Evidence-Based and Up-To-Date Guideline

Given that one in 100 children worldwide has autism (World Health Organization, 2022), there is a critical need for an interactive, adaptive, and customizable digital platform formed based on multidimensional findings and made publicly available. Furthermore, this platform should offer real-time educational content and guidelines for researchers, parents, caregivers, teachers of autistic children, and children with autism. As a result, these findings will provide a comprehensive understanding of how colors affect children with ASD. In essence, the objective of the digital platform, which includes a user-friendly, intuitive mobile app and web dashboard, is

to facilitate the diffusion of evidence-based data while allowing for essential compromises due to divergent user requirements, particularly for autistic children.

CONCLUSION

This need-finding study is perhaps one of the limited studies investigating the importance of the color effects as visual support to avoid sensory overload and attain an optimal setting for children with an autism spectrum disorder. More cross-contextual research and observations are required to investigate further and highlight the relationship between autism and colors. As of this writing, according to the Centers for Disease Control and Prevention (CDC), autism – a lasting multifactorial disorder that disturbs how ones perceive the surroundings and interact with others – is a common disability affecting one in 44 children in 2018 compared to one in 88 in 2008. Children with autism experience unusual sensations in their vision, hearing, and feelings. Visual supports are broadly used and considered for these children as a sufficient intervention. Color is the visual property of an object's pigment detected by the eye and produced due to the way the object reflects or emits light. Responses to color are both physiological and psychological. Future work to meet these needs will be directed at creating an interactive research repository to foster the exchange and development of knowledge/information and observation. Such a digital adaptive, interrelated repository would act as a visual guideline for parents, caregivers, teachers of autistic children, and persons with autism themselves.

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