An Approach to Design Sensory Furniture for Autism

by

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Abstract

According to the Centers for Disease Control, the prevalence rate of autism in the United States nearly tripled from 2004 to 2020. The rapid rise in the number of autism diagnoses places an economic burden on the United States and even the entire world. This issue requires people to pay attention and take appropriate action. This study will research the psychology and behavior of children with autism and seek to categorize their personality characteristics and physical needs with the goal of understanding whether and how furniture design can support early intervention treatment for children with autism. Current research shows that the sooner intervention treatment for children with autism is initiated, the easier it is for them to adapt to society. Since the home environment is very familiar to children with autism, it is proposed that indirect treatment in this environment will have a better effect, suggesting furniture with sensory input functions will play a significant role in the treatment of children with autism. This study aims to help increase children's learning efficiency with autism through early intervention.

Because of the diversity of characteristics of autism, it is challenging to create a simple set of criteria. This thesis is for developing assistive furniture without a broader exploration and understanding of user behavior and family needs.

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Chapter 1 Introduction

1.1 Problem Statement

According to the Centers for Disease Control, it is estimated that 1 in 54 children in the U.S. in 2020 are diagnosed with autism. As shown in Figure 1.1, the estimated number of autism diagnoses in 2018 was 1 in 59 children, compared to a 10% increase in the number of children with autism in 2020 (CDC, 2020).

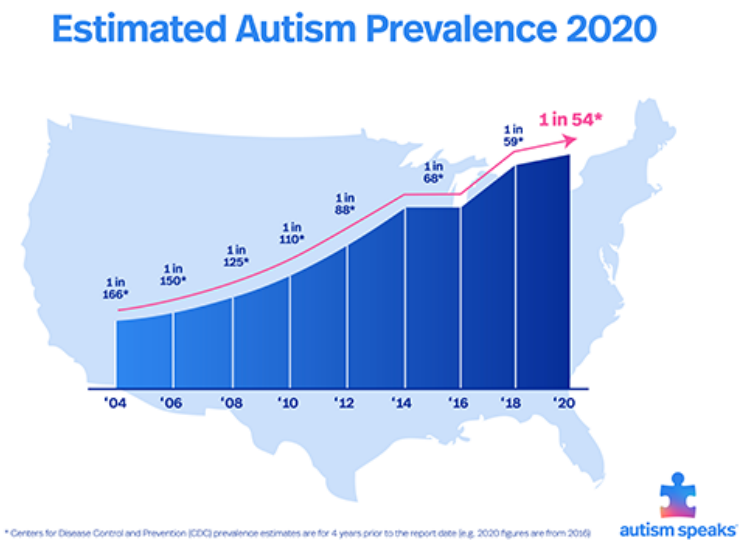

Figure 1.1 Estimated Autism Prevalence 2020

Researchers estimate that the United States spends between $236 billion and $262 billion annually to help children and adults with autism (ASD) (Buescher et al., 2014). Of this amount, early intervention comprises the majority of the costs during childhood with autism. Experiments have shown that due to the specific behavioral habits of autism, it is difficult to ensure that children with autism are able to focus on early intervention training even with the help of professional therapists (Troyb et al., 2016), which not only wastes valuable national resources but also impacts the future direction of children with autism.

Schilling and Schwartz (2004) suggest that children with autism in dynamic mode are more likely to achieve optimal brain focus and that interventions at home or in the classroom allow the children to be better able to learn efficiently. Because there are many different types of autism, teaching aids need to be updated to meet children's specific needs with autism. Research has shown that the proper use of teaching aids can increase student engagement in academic tasks and daily activities (Hemmingson & Borell, 2002), and the existing market for autism products often makes it difficult for teaching aids to escape the shape of medical devices that help create a comfortable and relaxing learning environment for children with autism. The official classification of these teaching aids does not indicate the areas of strength of the aids. It does not accurately address the specific needs of children with autism to design products that meet those needs. For example, parents blindly purchase different types of products when their child needs help with self-regulation. These problems not only waste financial resources but also slow down the child's training process.

1.2 Need for Study

After analysis and investigation of existing products in the market, the product for autism is still in the developmental stage, and parents of children with autism have difficulty choosing the right products for their children's specific needs because the market is not accurately categorized. Existing products are heavily medicalized in appearance and lack emotional care for children with autism, while systematic research on furniture design for children with autism is lacking.

Research has shown that early intervention training is the most effective method derived from years of practice (Lord, 1995) and that environmental changes on the emotional and learning efficiency of children with autism are noticeable (Salingaros, 2017). Learning in a

familiar home environment or a warm classroom environment improves children's concentration and learning efficiency with autism. Therefore, this thesis provides a theoretical basis for designing indoor furniture with early intervention for children with autism by systematically studying autistic children's psychological and behavioral characteristics and targeted intervention training methods. This thesis focuses on the study of the physical habits, psychological needs, and daily behavioral situations of autistic children. From an academic perspective, the design process will be executed in strict accordance with the design concept of industrial design. The design of furniture with early intervention training functions will promote the development of autistic product design through a reasonable conception.

1.3 Objectives for Study

- To study the history of autism
- To study the main signs and symptoms of autism
- To study physiological characteristics of children with autism
- To study psychological characteristics of children with autism
- To study treatment for children with autism
- To study behavioral characteristics of children with autism
- To research the current market of product for autism
- To develop an approach of using creative thinking to develop the product for children with autism
- To demonstrate an application of the developed approach with a hypothetical design project

1.4 Definition of Terms

Autism spectrum disorders (ASD) Pervasive Developmental Disorders (PDD) - any of a group of developmental disorders (such as autism and Asperger's syndrome) marked by

impairments in the ability to communicate and interact socially and by the presence of repetitive behaviors or restricted interests, also called pervasive developmental disorder (Autism Spectrum Disorder, n.d.).

Early intervention- Is the term used to describe the services and supports that are available to babies and young children with developmental delays and disabilities and their families. Includes speech therapy, physical therapy, and other types of services based on the needs of the child and family. Can have a significant impact on a child's ability to learn new skills and overcome challenges and can increase success in school and life (CDC, 2018).

Nonfunctional Routines - Nonfunctional routines are specified, sequential, and apparently purposeless repeated actions or behaviors that a child engages in, such as always lining up toys in a certain order each time instead of playing with them. Children with ASD may follow routines that appear to be senseless but may have significance to the child (Autism Speaks EN, n.d.).

Restricted and repetitive behaviors (RRBs) - Include a broad category of behaviors such as preoccupation with one or more restricted patterns of interest, adherence to specific, nonfunctional routines, repetitive motor manners, and preoccupation with parts of objects (Kim & Lord, 2010).

Sensory integration (SI) - The process by which people register, modulate, and discriminate sensations received through the sensory systems to produce purposeful, adaptive behaviors in response to the environment (Ayres, 1972).

Theory of mind (ToM) - The ability to attribute mental states to ourselves and others, serving as one of the foundational elements for social interaction (Ruhl, 2020).

1.5 Assumptions

It is assumed that all the research, approaches, methods and data I found are valid / reliable.

It is assumed that parents care about improving the efficiency of early intervention training for children with autism.

It is assumed that furniture can help children with autism to improve the efficiency of early intervention training.

It is assumed that furniture can provide a relaxing and comfortable environment for children with autism.

1.6 Scope and Limits

This thesis will only focus on the furniture aspect of the design and will not include medical equipment. The furniture is designed to create a sensory friendly environment for children with autism and has a mild therapeutic effect on autism.

The theoretical basis for this dissertation is mostly taken from Western literature, and individual research data may be valid only for the West.

This thesis focuses on furniture for children with autism; adult furniture will not be considered.

1.7 Procedures and Methodology

Procedure 1: Study the history of autism

Method: Library & internet research

Classify and summarize collected information

Procedure 2: Study physiological characteristics of children with autism

Method: Library & internet research

Classify and summarize collected information

Procedure 3: Study psychological characteristics of children with autism

Method: Library & internet research

Classify and summarize collected information

Procedure 4: Study treatment for children with autism

Method: Library & internet research

Classify and summarize collected information

Procedure 5: Study behavioral characteristics of children with autism

Method: Library & internet research

Classify and summarize collected information

Procedure 6: Summarize the psychological and behavioral characteristics and special needs of children with autism

Method: Library & internet research

Classify and summarize collected information

Procedure 7: Summarize the relationship between the characteristics of furniture and the special needs of children with autism

Method: Library & internet research

Classify and summarize collected information

Procedure 8: Classify the special needs of children with autism according to different treatment methods and develop an assistive furniture design process

Procedure 9: Apply the design approach to the design process of furniture for children with autism

1.8 Anticipated Outcome

The primary outcome is to help designers to design furniture that can improve the concentration and efficiency of learning for children with autism, and furniture designed with this proposed detail process can be used for different special needs and can serve more children with autism in order to help children with autism achieve better results in early intervention training and take the first steps toward future independence.

Chapter 2 Literature Review

2.1 Overview of the Development of Autism

Children are the beginning of a new chapter for many families, so research into the science of parenting has become a hot topic, and parents take a long time to prepare for the arrival of a child. But some unpredictable congenital disabilities can lead a family to face challenges and predicaments, one of which is autism.

Autism has been identified in medical history for over 90 years, but autism is still not well known in the realm of life. First, in 1925, Russian psychiatrist Grunia Sukhareva reported six similar cases of schizophrenic psychosis in children, and she described the personality disorder in these children, which was later translated into English by Wolff. Described as characterized by "tendency toward solitude and avoidance of other people" (Wolff, 1996, p. 129), it is now referred to as high-functioning autism. Subsequently, in 1938, Leo Kanner (1943) identified some unusual cases in children. These children lacked social connections, and most had intellectual disabilities, characteristics that Kanner referred to as autism (Kanner, 1943). A year later, Kanner (1944) published an article on early infantile autism and first used the term "infantile autism" .

Autism spectrum disorder (ASD) is a congenital, comprehensive psychological disorder that usually appears in early childhood. Its symptoms include restrictive and repetitive behaviors, abnormalities in social, interpersonal, communication patterns, a lack of desire to communicate with people and the environment, and a lack of ability to learn and imitate (American Psychiatric Association, 2013). These restricted and repetitive behaviors are also known as RRBs. RRBs reduce attention to and exploration of the environment and result in a lack of meaningful learning opportunities early in life (Troyb et al., 2016), which means that children with autism

have difficulty focusing on multiple objects. They need help to engage in meaningful learning. Children with autism are highly malleable, and the direction of development with or without early intervention is quite different. The "good direction" is that they can gradually become socially competent, self-caring, social and learning and even trained to perform a job and become self-sufficient.

The worldwide prevalence of autism in children is increasing every year. One in every 59 children has autism (CDC, 2020), placing an enormous economic burden on societies around the world to help the autistic community.

2.2 Essential Characteristics of Children with Autism

The main characteristics of autism are impairment in social interaction, lack of language and ability to cope with change, and repetitive stereotypical behavioral patterns (American Psychiatric Association, 2013). As shown in Figure 2.1, there are many different types of autism characteristics, and each individual will not have exactly the same characteristics.

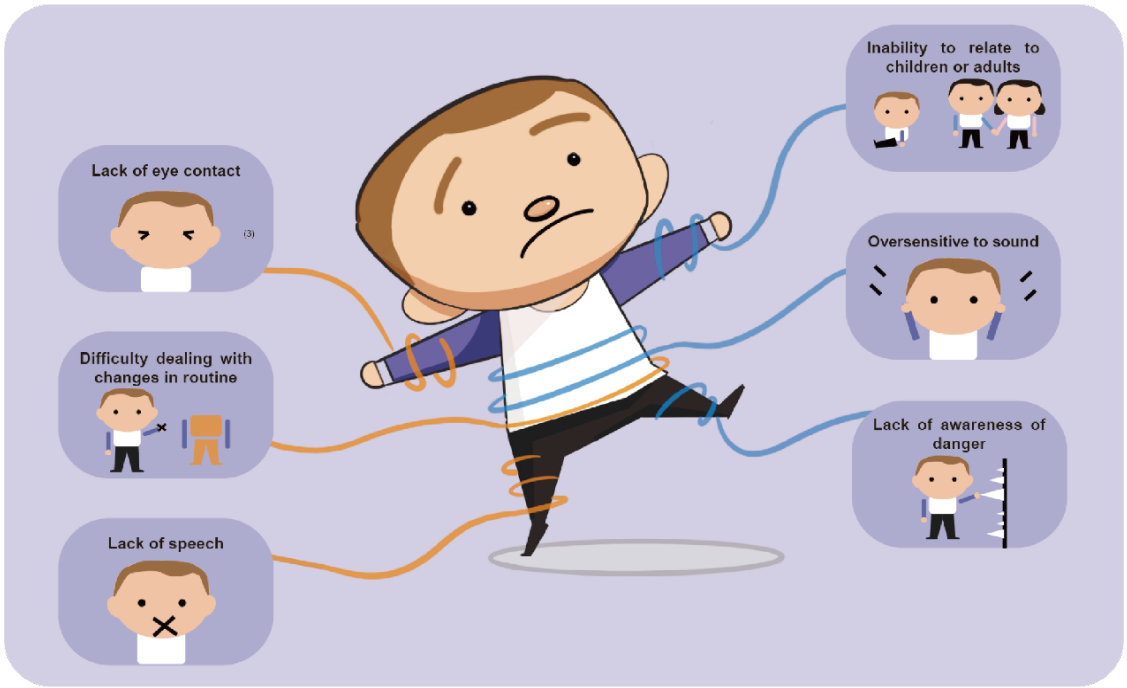

Figure 2.1 Characteristics of children with autism

2.2.1 Physiological Characteristics

Studies have shown that the brain's frontal lobe in children with autism has varying degrees of structural abnormalities (Belichenko et al., 1997; Coleman et al., 1985). Carper and Courchesne (2005) found that during the early stages of brain development in children with autism, the dorsal prefrontal cortex develops more rapidly than in normal children at age two years. At the same time, growth is very slow after age 2. Courchesne et al. (2003) found that children diagnosed with autism had a smaller than average head circumference at birth, with a rapid increase in head circumference between 6 and 14 months. The transient, localized increase in head circumference resulted in different effects on all brain regions. The dorsal prefrontal cortex is associated with the child's executive functions, thus affecting memory capacity and attention in children with autism (Curtis & D'Esposito, 2003). In contrast, the overdevelopment of cells in the dorsal prefrontal cortex affects the connectivity of other areas of the brain. This leads to cognitive dysfunction in the frontal regions.

2.2.1.1 Motor Development

"*Motor development refers to the development of a child's bones, muscles, and ability to move around and manipulate things in an environment.* Motor development can be divided into two sections: gross motor development and fine motor development" (Vladimir, 2020). Children with autism often have motor deficits and slow developmental problems. Their balance, agility, and imitation skills are lower than those of normal children (Jones & Prior, 1985). As shown in Figure 2.2, fine motor movements include building blocks, finger squeezing, pushing and pulling, and finger writing. Deficits in fine motor development determine the child's ability for hand-eye cooperation and hand strength and dexterity, which are deficits in children with autism. For example, children with autism are unable to hold a pencil and write normally, and they may color

out of the borders.

Figure 2.2 Baby Painting Fine Motor (Baby Painting Fine Motor, n.d.)

As shown in Figure 2.3, gross motor movement can help children to exercise their motor skills, which can be done by using apparatus such as balance beam and balance ball to exercise children's balance and body coordination. The lack of gross motor development negatively impacts children's overall motor skills, such as uncoordinated movements and poor balance problems. In summary, society should pay attention to the developmental motor disorders of children with autism because addressing these external physical conditions will help the child's learning path and help children with autism master basic daily living skills.

Figure 2.3 Gross Motor (Gross Motor, n.d.)

2.2.2 Psychological Characteristics

Theory of Mind (ToM) is a tool used to help researchers assess test takers' ability to empathize and sympathize. In 1985, Baron-Cohen et al. first used the theory of mind explanations to illustrate the psychological features of autism and found that individuals with autism often do not have a complete theory of mind. Delays in the development of empathy and sympathy contribute significantly to the impaired verbal communication and social development of individuals with autism.

2.2.2.1 Social Development Disorders

According to McFall (1982), social-communicative competence includes externalizing behaviors, physical and cognitive. Episodic behaviors are social-communicative behaviors that can be observed, such as eye contact and emotional expression. Physiology refers to the performance of human systems such as breathing and heartbeat, and cognitive refers to the human behavior of decision-making and processing of information. The presence or absence of developmental disorders of socialization in different individuals can be determined by three aspects, which are behaviors, physical and cognitive. Kanner (1943) first described autistic children as lacking social connections. The developmental impairment of socialization proved to be one of the most observable features of autism.

Developmental socialization disorder refers to the patient's inability to understand the emotions and feelings of others and to express their own emotions and feelings correctly. There is a lack of tendency to interact and communicate with others. The long-held stereotype of people with autism is that they are unable to understand emotions. It is true that many people with autism do not express their feelings in the same way that ordinary people do. However, the

general perception that people with autism do not identify with emotions is wrong. This perception distorts the perception of people with autism. As a high-functioning autistic person, Robison (2008) believes that people with autism sometimes show the same or even more emotions than the average person. He explains that "Many descriptions of autism and Asperger's describe people like me as ‘not wanting contact with others’ or ‘preferring to play alone’" (p. 211). From the inside, children with autism crave companionship, but they don't know how to express themselves or how to get along with other children.

2.2.2.2 Emotional Control Disorders

In 1872, Charles Darwin published his book *The Expression of the Emotions in Man and Animals*. In the book, he argues that humans are born with facial recognition and emotional expression and that in early human childhood, infants can spontaneously express expressions of joy, sadness, and disgust (Darwin & Prodger, 1998). Brewer et al. (2016) found that when people with autism were in their own emotions, they expressed their feelings less frequently than ordinary people, and expressions were vague, from facial expressions to language. It has been found that children with autism are unable to match information gathered from the outside world with expressions. They have difficulty extracting valid emotional expressions from sounds, as well as difficulty in making correct expressions of emotions and lack empathy (Hobson, 2014). Hill et al. (2004) found that children with autism have emotional control deficits specifically in the form of emotional apathy, avoidance of eye contact with others and they suggest that children with autism are emotionally indifferent, avoid eye contact, and do not know how to express their emotions verbally.

This is also confirmed according to Hobson's research (1993), which shows that individuals with autism have deficits in the comprehension of emotions and differ from the norm

in their ability to imagine and describe emotions. Hobson noted that the cognitive deficits lead to an inability to think about the thoughts of others, which leads to a lack of empathy. In summary, emotional interaction is very difficult for children with autism. The inability to understand others as well as express their emotions will make it difficult to establish good peer relationships.

2.2.2.3 Language Communication Barriers

Due to congenital brain function deficits, children with autism have language dysfunction and are unable to express their communicative intentions accurately. According to autism writer Naoki Higashida (2016), people with autism generally avoid looking at each other because eyes frighten them. There is a lack of interest and response to human voices, reduced cognitive ability to navigate the environment, and little sense of self-learning. In fact, all this is because children with autism are limited in their ability to think abstractly, which leads them to understand words literally and not the essence of the problem, so verbal communication is challenging for children with autism because they cannot select the substance from the language. Besides, children with autism usually do not initiate verbal communication with others in a way that satisfies their own purposes (Charman et al., 1997).

Early intervention is important to help children with autism across the language barrier, as verbal communication is the first step in mastering new learning opportunities for children with autism. Differences in language communication can affect the progress of early intervention for children with autism, resulting in missing the optimal time for early autism intervention (ages 2-6) (CDC, 2018).

Verbal communication and imitation are closely related, and Stone and Yoder (2001) suggest that a deficit in language skills in children with autism also implies impaired imitation. Research has shown that children with autism do not usually imitate sounds and body

movements independently (Dawson et al., 1998). This also means that children with autism have significant limitations in their ability to learn. Studies have shown that infants are capable of both play and verbal expression by 20 months of age (Charman et al., 1997; Ungerer & Sigman, 1984). The lack of verbal communication skills in children with autism also leads to a concomitant decrease in the child's ability to play. During play, children with ASD often do not explore objects on their own (Pierce & Courchesne, 2001), which affects their expressive and motor development.

2.2.3 Perceptual Characteristics

In 1972, Dr. Ayres proposed Sensory Integration, a theory that refers to the process by which the human body receives different types of sensory information from the outside world by each sense, and the brain receives and responds to different behaviors.

Sensory integration is divided into five primary senses: tactile, auditory, visual, gustatory, and olfactory, and two other senses: vestibular and proprioception (DiMatties & Sammons, 2003). In early childhood, sensory integration determines the speed at which a child receives information from the outside world and thus determines the child's ability to learn. Therefore, early sensory integration interventions are necessary and determine the child's physical and psychological development. But if the nervous system elements do not collaborate with each other, the failure of ontogenetic contact with the environment is known as dysfunction in sensory integration. Ginn et al. (1981) consider dysfunction in sensory integration as a major characteristic of children with autism.

Dysfunction in sensory integration was described by Lane et al. (2000) as "the inability to modulate, discriminate, coordinate or organize sensation adaptively" (p. 2). It has been shown that children with autism typically have sensory integration deficits in auditory, visual, tactile,

vestibular, and proprioceptive sensations (Dunn, 2002). There are two theories of sensory integration disorders, the first being Over-arousal theories. Over-arousal theories refer to sensory over-stimulation disorders caused by under-functioning of the integrative system and are the main cause of sensitivity and irritability in children with autism. "Stimulus overload" is caused by misallocation of attention, and Hutt et al. (1964) suggest that stereotyped and repetitive behaviors in autistic children can reduce sensory over-arousal.

However, Rogers and Ozonoff (2005) argue that the use of stereotyped and repetitive behaviors to reduce over-arousal can also exacerbate the development of stereotyped behaviors, leading to greater resistance to new things in children with autism. The second is the under-arousal theories (Rimland, 1964), which refer to deficits in sensory stimulation caused by inadequate functioning of the sensory integration system, resulting in the inability to receive information transmitted through the senses. However, children with autism can compensate for under-arousal by increasing their stimulation through stereotyped and repetitive behaviors that help the senses to receive more information.

2.2.3.1 Sound – Auditory

The ability to accurately receive and analyze auditory information is deficient in people with autism. Studies have shown that individuals with autism are sensitive to loud environments, especially to sudden and loud sounds, such as barking dogs. In addition, individuals with autism are sensitive to continuous, high-pitched sounds, such as those from electrical appliances (Attwood, 1998; Birch, 2003; Grandin, 2005; Grandin, 2006).

Auditory evoked brainstem research has demonstrated the slow ability of the auditory system to process information in individuals with autism, especially when individuals with autism are in more complex environments, such as noisy shopping malls (Fujikawa-Brooks et al.,

2010; Magliaro et al., 2010; Rosenhall et al., 2003). Remarkably, children with autism have developed well in the area of music despite their language communication impairment. Mottron et al. (2000) found advantages in the area of music for individuals with autism in their experiments, where they were able to discriminate changes in musical melodies more easily than non-autistic individuals. Heaton et al. (1999) found that children with high functioning autism were able to discriminate pitch changes more accurately.

2.2.3.2 Touch - Tactile

Tactile means the sense of touch. Because there are two different theories of sensory integration disorders, over-arousal theories and under-arousal theories (Hutt et al., 1964; Rimland, 1964) are applied to the sense of touch in the same way; children with autism are usually over-or over-insensitive to touch. This can lead to difficulties fraught with activities of daily living for individuals with autism. Studies have shown that 95% of parents report abnormal reactions to both food and clothing textures in their children (Rogers & Ozonoff, 2005). Even the simple act of dressing and brushing teeth may cause resistance in children with autism as they grow up.

2.2.3.3 Smell - Olfactory / Taste – Gustatory

The senses of smell and taste are important for feeding behavior, and studies have demonstrated that most individuals with autism have restrictive and atypical eating habits (Schreck & Williams, 2004; Schreck & Williams, 2006). The study concluded that "Difficulty in identifying basic tastes and smells may contribute to high rates of food refusal and selectivity reported in children with autism" (Bennetto et al., 2007).

From a neurophysiological perspective, the senses of smell and taste are sensed by two sensory systems involved in stimulus responses, namely the olfactory nervous system and the

nasal trigeminal nervous system. The senses of smell and taste will play a mutually integrating role. Olfaction is a distant sense, which is reflected by the perception of chemical stimuli over long distances. In contrast, the taste is a proximal sense, which is reflected by the tongue (Simon et al., 2006).

Researchers have found that humans have an excellent olfactory system in infancy and slowly acquire the ability to give meaning to odors as well as the ability to perceive odors and their characteristics as they age (Rabin, 1988; Stockhorst & Pietrowsky, 2004). Tonacci et al. (2017) demonstrated the presence of autistic individuals through their study of olfactory impairment. Bennetto et al. (2007) concluded that children with autism have a lower ability to recognize odors. Therefore, children with autism are less sensitive to gases and require higher concentrations of stimuli to respond to them. Muratori et al. (2017) concluded through their study that olfactory dysfunction in children with autism is due to damage to the cerebral cortex that not only leads to a lower ability to recognize gases in children with autism but also to a greater sensitivity to external stimuli.

The gustatory system is stimulated by nerve cells through olfactory glomeruli, and each olfactory glomerulus can only stimulate one exclusive nerve cell, so the characteristics of each message are retained by different nerve cells. Nerve cells that retain different gases can help humans perceive and recognize different gases (Bell & Parr, 2015; Holley, 2006).

Studies have shown that children with autism often have severe eating behavior problems, which are manifested by picky eating and specific eating habits, such as using only specific utensils and eating only specific foods (Lane et al., 2014). Eating behavior problems can lead to incomplete skeletal development and behavioral disturbances in children with autism. It is believed that eating behavior problems add invisible stress to the family and increase the anxiety

that children experience when eating. Parents have the greatest impact if eating behavior problems are to be improved (Angell, 2010).

2.2.3.4 Sight - Visual

Studies have identified reduced activity in the superior temporal sulcus (STS) as an important reason for the abnormal development of visual processing skills in individuals with autism (Pelphrey et al., 2005). The abnormal visual ability leads to resistance to eye contact, which is an important reason for the lack of social communication in autistic individuals. On the other hand, because people with autism see the world differently, some studies have shown that people with autism have an advantage in fine details and finding hidden things, and they are more likely to detect changes in detail (Shah & Frith, 1983). Children with autism typically use limbic vision rather than central vision and are accustomed to gazing at everything that appears around them with their afterglow, acquiring visual information through multiple sweeps. These children are unable to coordinate their frontal and limbic vision properly, and when asked to look at objects that are moving, their eyes cannot accurately follow the moving objects.

On the other hand, because individuals with autism view the world from a different perspective, some studies have shown that individuals with autism have an advantage in fine details and finding hidden things, and they are more likely to detect changes in detail (Shah & Frith, 1983). In addition, some autistic individuals have a definite advantage in the area of drawing, which stems from their obsession with detailing (Mottron & Belleville, 1993). The over-obsession of autistic people with the details of objects also causes their vision to ignore the object as a whole (Frith, 2003). This means that autistic individuals are unable to get meaningful information from the object as a whole. It was found that individuals with autism performed better in reproducing impossible figures (Mottron et al., 1999), Brosnan et al. attributed this to

impaired visual observation skills, which resulted in distracting individuals with autism from observing the structure of impossible figures (Brosnan et al., 2004).

2.2.3.5 Vestibular

In 1892, Ewald first used the term "vestibular", which is located in the anterior part of the brainstem under the posterior part of the brain and is responsible for providing information to the brain about spatial orientation. The vestibular system helps humans to integrate the input from the sensory system and control the output of body movements. Vestibular dysfunction causes difficulties with gravity, balance, and movement in children with autism. These difficulties may lead to slow development of the motor system in children with autism, lack of gravity to walk and fall easily, hyperactivity and anxiety, inattention, inattentiveness during learning and activities, and inability to move autonomously in children with intense weightlessness.

2.2.3.6 Proprioception

In 1893, Sherrington first used the term "proprioception," defined as the sensation of stimuli that "are traceable to actions of the organism itself" (Sherrington, 1952). Miyahara (2013) argues that the ability to control the body is important for the development of daily motor functions in humans, and research has shown that children with autism typically exhibit uncontrolled back and forth swaying of the body when standing still and do not have good control of the body (Traver et al. 2013). Therefore, poor proprioception's specific manifestations in children with autism are the poor sense of direction, inability to avoid objects, poor balance, poor motor skills, and inability to estimate spatial scales.

2.2.4 Atypical sensory behaviors

Atypical responses to sensory stimuli have been described as 'hyper- or hyporeactivity to sensory input' (APA, 2013). Bar and Neta (2007) suggested that social cognitive impairment in

children with autism is an important cause of developmental deficits in sensory integration, and Simmons et al. (2009) found that over 90% of children with autism exhibit varying degrees of atypical sensory behaviors during social interactions. From the perspective of behavioral responses, the threshold of the human nervous system is divided into two different response strategies, a) passive response strategies in the face of different situations and b) active response strategies in the face of different situations.

Dakin and Frith (2005) suggested that the behavioral responses of children with autism are divided into four responses in the interaction of the threshold of the nervous system and self-regulation (Table 2.1.), discussed below.

NEUROLOGICAL THRESHOLD CONTINUUM	BEHAVIORAL RESPONSE CONTINUUM Accordance	 Counteract
High	LOW REGISTRATION Factor 3 (low endurance/tone) Factor 6 (poor registration) Factor 8 (sedentary) *Expected physiological response* to *sensation is a weak response* (due to high threshold) and *quick habituation* (due to accordance behavior that continues to limit response)	SENSATION SEEKING Factor 1 (sensation seeking) Expected physiological response to sensation is a weak response (due to high threshold) and slow habituation (due to counteract behavior that pursues sensation)
Low	SENSORY SENSITIVITY Factor 4 (oral sensory/sensitivity) Factor 5 (inattention/ distractibility) Factor 7 (sensory sensitivity) *Expected physiological response to sensation is strong response* (due to low threshold) with *slow habituation* (due to accordance behavior that involves a sustained recognition of available sensation)	SENSATION AVOIDING Factor 2 (emotionally reactive) Factor 8 (sedentary when motivation is to keep away from sensory experiences) *Expected physiological response to sensation is a strong response* (due to low threshold) with *quick habituation* (due to counteract behavior that withdraws from sensation)

Table 2.1 Model of Sensory Processing (Dunn,1997)

a) Low registration, Dunn (2007) defined "low registration" as a sensory processing mode. When children with autism have a low registration response strategy, their responses are

usually characterized by a focus on details. When children with ASD have a low registration response strategy, their responses are usually characterized by a neglect of details and a slow or no response to things. As a result of this sensory processing mode, children with autism have less access to sensory information, are less susceptible to interference, and have a more relaxed personality.

b) Sensory seeking, Individuals who seek sensory stimulation have an inadequate ability to gather stimuli from their senses, and therefore, they require increased sensory stimulation to function properly. Individuals with this type of reflective strategy are usually active and irritable. They require a large amount of stimulation to gather enough information through sensory integration to reach an optimal level of arousal, e.g., children with autism swing their bodies back and forth to increase external stimulation. It is important for children with this type of autism to increase opportunities for sensory experiences. Otherwise, they may be distracted by self-stimulation in their daily activities, which may compromise the effectiveness of the intervention (Dunn, 2001).

c) Sensation avoiding. Most sensory avoiders are overreactive or hypersensitive. They are so reactive to sensory input that even the slightest touch or sound may cause negative behavioral responses and anxiety in this type of autistic child. As a result of overreacting to sensory input, they often avoid certain sensations, sounds, or environments, for example, refusing to wear certain materials of clothing. Individuals who have this type of reflective strategy usually appear timid.

d) Sensory sensitivity, when children are more responsive in sensitivity, their awareness of sensory events is somewhat faster than others. Because these children are more likely to detect

sensory events, one may find that they are more easily distracted and upset than other children （Gopal & Raghavan, 2018).

2.2.5 Behavioral Characteristics

Individuals with autism all differ in specific behavioral characteristics, but all have varying degrees of repetitive, stereotyped behaviors and impairments in communication and social development.

2.2.5.1 Restrictive Repetitive Behavior (RRB)

In 1999, Turner first defined restrictive, repetitive behavior as repetitive unvarying behavior or action that he believed had no clear purpose or function and was often described as repetitive, stereotyped, unchanging, and inappropriate. The DSM-5 describes the following criteria for defining restrictive, repetitive behavior in autism: (a) This includes physically repetitive behaviors with no apparent purpose, such as head-slapping, body shaking, and finger chewing. (b) It is a highly restricted interest and a single and obsessive interest in a localized feature of an object. (c) It follows a strict behavioral or verbal sequence and starts over if the behavior or language is interrupted. (d) It is over-or under-responsiveness of the senses to information processing, e.g., no response to pain (American Psychiatric Association, 2013).

Later, Bodish et al. (2000) classified repetitive stereotypic behaviors into compulsive behaviors, stereotypic behaviors, self-injurious behaviors, ritualized behaviors, uniformity behaviors, and narrow interests. Among them, self-stimulatory behaviors (SSB)-are frequent repetitive stereotypic behaviors that do not cause physical harm to the children themselves. These behaviors are usually manifested by shaking the body, running, etc. Self-injurious behaviors (SIB) are behaviors that allow children to injure themselves. These behaviors include hitting themselves or eating foreign objects.

Restrictive, repetitive behaviors arise because abnormalities in the sensory integration of children with autism affect their processing and processing of external information, resulting in abnormal stereotypic behaviors. Therefore, the living environment can also influence or ameliorate stereotypic behavior, and research has found that the incidence of stereotypic behavior in children with autism increases in more complex environments and decreases in reasonably planned environments (Clark et al., 1981). Children with autism in complex environments exhibit varying degrees of abnormal stereotyped behavior, and to help themselves adjust to the anxiety associated with their environment, children with autism seek a sense of order from stereotyped behavior. Berkson (1983) writes that "The repetitive and rhythmic nature of stereotypy is accounted for by suggesting that repetition in a rhythmic way is the most efficient way of self-stimulation". Solomon (2014) similarly stated that "Researchers would eventually discover that autistic people stim to reduce anxiety—and also simply because it feels good. In fact, harmless forms of self-stimulation (like flapping and fidgeting) may facilitate learning by freeing up executive-functioning resources in the brain that would otherwise be devoted to suppressing them".

There are five reasons why children with autism engage in self-stimulation: (a) Overstimulation occurs when children with autism have an overreaction to sensory processing of information and too much information is collected by sensory integration. Some specific self-stimulation behaviors can help the child itself to exclude the input of excess sensory information collection. (b) Under stimulation occurs when a child with autism has a low sensory response to information processing and insufficient information is collected by sensory integration, and appropriate self-stimulation can help the child provide the sensory information input that the body needs. (c) When a child with autism has physical pain, the child engages in self-stimulation

to help reduce the pain for him/herself, for example by repeatedly tapping on the head or other parts of the body to reduce pain in other areas. (d) When a child with autism has an extreme emotional response (extreme happiness or sadness), the extreme emotions can lead the child to engage in self-stimulatory behaviors, such as clapping or stomping the feet through their own means to help themselves manage the extreme emotions. (e) Benign self-stimulation can also help the child with autism to self-regulate by helping the child to relax through self-stimulating behaviors. In summary, children with autism do not receive enough stimulation during normal social activities, so they need to increase the reception of external stimuli with repetitive self-stimulatory behaviors. Conversely, when they receive too many external stimuli, they need to reduce the input of external stimuli by self-stimulatory behaviors.

2.2.5.2 Distracted Attention

Maintaining attention is an integral part of the learning process; however, attention deficit or hyperfocus is a common characteristic of children with autism and can lead to severe developmental limitations in children with autism. Attention is composed of four different dimensions: stability, breadth, allocability, and transferability (Mirsky et al., 1999). (a) Stability of attention refers to how long attention to a selected object can be steadily maintained. For example, a child can sustain attention during a lesson, while a child with autism often wanders and drifts off during a class, resulting in inefficient learning. (b) The breadth of attention refers to the amount of different information that can be clearly perceived and recognized in a single moment, e.g., some people can see ten things at once, but children with autism cannot receive too much information at the same time. (c) Distribution of attention refers to the ability to process multiple things at the same time, such as reading a book while listening to music. But children with autism have difficulty dividing their attention between multiple things at once. (d)

Attention shifting refers to the ability to understand priorities and shift attention to the primary task based on the classification of the task. For example, children with autism who have just completed one activity may have difficulty engaging in the next activity. This is the main reason why children with autism have limited interests and development.

Happe and Frith (1996) noted that children with autism place too much emphasis on the external details of objects, resulting in neglect of the essence of the object, a behavior also known as impaired central coherence. There are several different types of attentional disorders in children with autism, including (a) The inability to maintain attention autonomously and the difficulty in maintaining attention on one object. (b) Impairment in executive ability, where the child with autism has difficulty receiving several different types of information at the same time, is manifested by slow information processing. (c) Disorders of attentional shifting. Children with autism do not know how to regulate their attention, as evidenced by the difficulty in shifting from one stimulus to another, which is an important cause of repetitive, stereotyped behavior in children with autism. (d) The inability to allocate resources to attend and to distinguish priorities is an important cause of the lack of parent-child attachment in children with autism (Greg & Eric, 2001). Research has shown that children with autism have difficulty shifting their attention from parts to objects as a whole (Plaisted et al., 1999; Rinehart et al., 2001). Children with autism are influenced by external factors that affect the establishment of emotions towards their mothers during their contact with them. External factors such as the mother's glasses or curly hair may appeal to the child with autism. Because of impaired allocation of resources to attend, children with autism do not recognize their mothers, but only these external factors.

2.2.5.3 Circumscribed Interests

Circumscribed interests (CI) are defined as the intensity and focus of interests or attentional focus abilities of individuals with autism that become different from normal (Boyd et al., 2007). A restricted interest is defined as a state of showing an obsession with a single interest within a narrow range of subjects. Research has demonstrated that individuals with autism typically organize their daily activities strictly around these interests. In addition, restricted interests deepen with age (South et al., 2005), and Attwood (1998) suggests that these interests affect the development of social interaction skills in individuals with autism because they do not talk to others about things other than their own interests.

Circumscribed interests are a relatively specific behavioral characteristic of autistic patients, and it has been identified as an advanced stage of restricted, repetitive behavior because it is usually found in high-functioning autistic patients (Epstein et al., 1985; Turner, 1999). According to a summary of the literature by South et al. (2005) and Adams (1998), circumscribed interests usually have four properties: (a) the patient's living environment has a great deal of information about that interest, (b) it is difficult to change the patient's definition of that interest, (c) the interest is maintained for a very long duration, and (d) a great deal of time is spent on that interest. The development of circumscribed interests will lead to impairments in learning and social interaction and can even interfere with the child's daily life. Harrop et al. (2019) wrote, "Circumscribed interests in ASD often represent islands of ability for individuals". So, from another perspective, circumscribed interests also provide a sense of well-being for people with autism (Mercier et al., 2000).

2.3 The importance of Early Intervention for Children with Autism

The current treatment modalities for autism are early intervention and medication. The focus of intervention therapy is to improve the child's physical, psychological, and behavioral

styles (Warren et al., 2011). Early intervention therapy originated in the 1960s when Meisels and Shonkoff (2000) identified the ages of 0-5 as a rapid stage of language development and the ages 5-6 of as an important stage of heart development. Therefore, 0-6 years is an important stage in the child's overall rapid development and the best time to receive therapy. Therefore, early intervention at a younger age has tremendous benefits for the child's development.

As research progressed, experts studying children with autism found that children can be diagnosed with autism when they are only two years old (Lord, 1995). Therefore, children with autism in the 2–6-year-old stage are in an important period in determining development. This finding can help children to receive early intervention treatment earlier so that they can grow up with the ability to take care of themselves and better integrate into society.

2.4 Therapeutic Approaches to Intervention Training for Children with Autism

Children with autism are congenitally deficient in verbal and social communication skills, and if left to develop without appropriate interventions, they will be mentally and physically disabled. There are a number of therapeutic interventions for children with autism, the most widely known of which are the TEACCH Model (Marcus et al., 1978; Mesibov, 1997; Schopler et al., 1982), Applied Behavior Analysis (Skinner, 1953), naturalistic teaching (Buffington, Krantz, McClannahan & Poulson, 1998; Hwang & Hughes, 2000; Pierce & Schreibman, 1995), The LEAP program (Bartak & Rutter, 1973), Cognitive-Behavioral Therapy (Beck, 1970; Ellis, 1962), Developmental Intervention (Greenspan & Wieder, 1997; Rogers & Lewis, 1989) and Deep Pressure Therapy (Grandin & Scariano, 1986).

Silberman (2015) wrote that "Our therapeutic goal must be to teach the person how to bear their difficulties. Not to eliminate them for him, but to train the person to cope with special challenges with special strategies". The goal of early intervention therapy is for children with

autism to have the courage to face problems independently and the ability to solve problems independently. These early interventions require the active cooperation of the family and take approximately 12-36 hours per week to complete. Notbohm (2012) wrote that "Parents have become not just advocates, but emissaries. Being an autism parent today requires not only stamina, curiosity, creativity, patience, resilience, and diplomacy—but the courage to think expansively and to dream accordingly". Therefore, parents play a very important role in the treatment of children with autism. Parents need to be patient enough not to lose sight of the child's behavior and language, taking time out to be with the child and making the child feel loved.

2.4.1 TEACCH

TEACCH is also known as *Treatment and Education of Autistic and Related Communication-Handicapped Children*. The program was developed and founded by the late Eric Schopler, Ph.D., in 1972 to provide assistance to individuals of all ages with autism (Marcus et al., 1978). "The TEACCH program is a statewide, community-based intervention program that emphasizes environmental organization and visual supports, individualization of goals, and the teaching of independence and developmental skills" (Corsello, 2005).

This instructional program focuses on helping children build their future independence by four specific key mechanisms: (a) the instructional environment and activities are easy for the person with autism to understand and adapt to; (b) take advantage of the detailed visual aspects of the person with autism to help complement his weaker aspects; (c) focus on the interests of the person with autism to keep him actively engaged in learning; and (d) encourage spontaneous behavior of the person with autism. In TEACCH, the term "structure" refers to the arrangement of time and environment with the goal of helping individuals with autism learn more efficiently.

The second point is to avoid the autistic person facing the door or window, which can better reduce distraction. The temporal structure of TEACCH refers to the use of objects to help the autistic person transition from the previous activity to the next, for example, giving a spoon to cue that activity should translate into eating (Mesibov & Shea, 2010).

Boucher and Lewis (1989) showed that written instructions are more easily understood by children with autism, and Sarokoff et al. (2001) suggest that written or picture-based approaches are more effective in enhancing communication in children with autism. Therefore, TEACCH is generally taught in a written or pictorial format.

2.4.2 Applied Behavior Analysis ABA

Research has shown that applied behavior analysis (ABA) has become one of the most powerful and mainstream approaches to treating individuals with autism in recent years (Alves et al., 2020). In 1953, Skinner first summarized behavioral principles from observing the behavior of small animals and believed that they could be applied to humans. Later Bailey et al. (2010) demonstrated that the application of behavior analysis was the most effective way to address the needs of children with ASD (Friman, 2010). In 1968, applied behavior analysis was defined by Baer, Wolf, & Risley (1968). They argued that ABA is composed of seven different dimensions: application, behavior, analysis, technology, concept-based systems, effectiveness, and addressing general behavior. Where application refers to significant behaviors, behavior refers to behaviors that can be defined, and analysis refers to demonstrating that interventions contribute to behavior change and are clear enough for others to understand and learn from the results that achieve the same purpose.

ABA contains many different types of specific interventions based on behavioral principles, the most widely known of which are the Lovaas intervention (Lovaas, 1987) and

discrete trials (Maurice, 1993). In particular, Lovaas' research experiments resulted in the first positive effects in the history of autism. These interventions require one-on-one instruction, beginning with a simple interaction, imitation, and progressing to language application and emotional expression. Once the child has mastered the one-on-one component, they can practice these skills with other children (Corsello, 2005). Research has shown that ABA is effective in helping children with autism increase their ability to make eye contact and communicate with others, as well as helping to reduce behavior problems (Sheida, & Zaynab, 2020).

2.4.3 Naturalistic Teaching

Naturalistic teaching involves eye contact between the instructor and the child, behavior, traditional gestures, etc. that use the person's own behavior to increase the child's social interaction and communication and create a positive impact, and Buffington et al. (1998) and others found that naturalistic teaching helped children with autism improve their attention (Hwang & Hughes, 2000; Pierce & Schreibman, 1995). Naturalistic content is generally chosen by the child and can vary according to the child's interests. Naturalistic content is usually not in a prescribed order, and teachers can make different prompts depending on the child's response (Delprato, 2001).

Naturalism consists of the following three approaches: (a) Incidental teaching (IT), (b) Pivotal response training, (C) Script-fading.

IT is one of the most widely known naturalistic intervention programs available. Incidental teaching was first discovered and used by Hart and Risley (1968), and the program was designed to promote verbal communication skills in children with autism. IT is taught in an environment that focuses on arousing the interest of the child with autism, for example, by using materials that interest the child or by providing a fun activity schedule.

Pivotal response training is also a common naturalistic intervention procedure today. The goals of pivotal response training are threefold: (a) to help children respond correctly to different stimuli, (b) to increase children's self-management skills, and (c) to increase the number of time children spend in their natural environment. Pivotal response training is taught by four main components: (a) teaching children to make their own choices, (b) using naturalistic forms of teaching aids such as gestures, (c) teaching new skills based on already acquired skills, and (d) strengthening the child's ability to self-initiate (Koegel et al., 1999) Koegel et al. argue that pivotal response training can help children improve many behavioral problems. They wrote that "behaviors that are central to wide areas of functioning such that a change in the pivotal behavior will produce improvement across a number of behaviors" (p. 577). With the help of pivotal response training, children are able to respond autonomously to different environments.

Script-fading is the last of the more common naturalistic intervention procedures that use scripting as a tool to improve the social communication skills of children with autism. In situations where children with autism respond with an inability to use verbal communication, Script-fading helps children with autism to better understand and use language using a combination of visual and auditory senses (Krantz & McClannahan, 1993).

2.4.4 The LEAP Program

The LEAP program is also known as Learning Experiences and Alternate Program. It is more comprehensive, and its main goal is to help children improve communication skills, regulate emotions, and promote social development purposes (Boyd et al., 2014). LEAP requires a structured educational environment and uses visual supports to help children understand language and tasks (Mesibov, 1997). Visual support refers to the Picture Exchange Communication System (PECS), which entails the use of picture cards to help with the

application, and children can express their needs by exchanging picture cards (Bondy & Frost, 1994).

Nind and Hewett (2001) point out that LEAP also applies reinforcement interactions that reinforce children's communication skills through nonverbal means, such as using eye contact and facial expressions to express themselves, similar to the interactions between infants and parents. The LEAP program is an intervention program in which peers are placed in a group, because research has shown that children with autism have difficulty learning how to interact with their peers from adults (Bartak & Rutter, 1973). Thus, this program can better help children increase their social interaction.

2.4.5 Cognitive-Behavioral Therapy CBT

Beck (1970) and Ellis (1962) pioneered **Cognitive-Behavioral Therapy** (CBT) by arguing that mental disorders are the result of an individual's cognitive behavior and that if negative perceptions can be accommodated, it can help patients alleviate their internal distress and behavioral impairments. CBT therapy modalities include visual elements, social skills training, child interest, and family involvement (Kose et al., 2018; Neil & Sturmey, 2014). The primary aim is to be used to treat emotional problems in individuals with autism and to help patients recognize and understand how their behaviors and emotions interact with each other. It is known that many people with autism suffer from psychological problems such as anxiety and depression (Kim et al., 2000; Maskey et al., 2013). CBT is the most commonly used intervention for treating psychological problems such as anxiety and depression in autism, and many studies have demonstrated its therapeutic effectiveness (Kester & Lucyshyn, 2018; Kreslins et al., 2015).

CBT has two main components: (a) Using cognition as a tool to change the child's perception of different situations, and (b) changing the child's response to the situation through

behavior. In CBT, the therapist uses cognition to help the child with autism understand their problems and break them down into smaller pieces so that the child with autism can better understand and solve them. In this way, children with autism will more easily discover how these smaller parts are connected and how these problems affect their thoughts and emotions. The therapist explores different situations, emotions, and behaviors. When children with autism learn to identify these different elements, they can easily identify the problem, understand the impact of the problem, and solve it. Through CBT, patients can learn to replace negative thoughts with more positive ones.

2.4.6 Developmental Intervention

Developmental intervention is when the child initiates the behavior and the adult responds and guides. This type of intervention is child-led, and the adult is expected to follow the child's thoughts and provide the correct guidance. One of the best-known approaches is called The Greenspan Model, also known as the Developmental Individual Difference (DIR) Model (Greenspan & Wieder, 1997). Its goal is to help children develop interpersonal relationships, including attention, nonverbal gestures, and logical thinking skills (Corsello, 2005).

The Denver model (Rogers & Lewis, 1989), also an approach to developmental intervention, is based on playful situations to maximize the child's interest and help the child respond and communicate. Children make many gains in language and emotional development (Corsello, 2005).

2.4.7 Deep Pressure Therapy

A common symptom in many autistic individuals is anxiety and stereotyped behavior (Hardy, 1990), and Hutt et al. in 1965 noted that EEG patterns in autistic children indicate high levels of arousal. This suggests that stereotyped behavior increases with external stimuli. In the

Ayres report (1979), it was demonstrated that sensory input was provided with motor mat wraps with the aim of calming the autistic child physically and psychologically. This report demonstrated that deep pressure could reduce excessive anxiety or excitement in autistic children.

In 1986, Grandin and Scariano also presented the idea that the tactile system and deep pressure are important for the early intervention treatment of autistic children. As a high-functioning autistic person, in her book, she describes her desire for deep pressure and the stress and anxiety that unknown touch brings to her. While she was in college, she designed and developed the hug machine, which helped her learn to tolerate touch and reduce anxiety and tension (Grandin & Scariano, 1986).

Research has shown that therapists can significantly reduce stereotypical behaviors and improve student attention in children with autism by using weighted clothing and chairs with squeeze features (Fertel-Daly et al., 2001).

2.5 Reasons Affecting the Effectiveness of Interventions for Children with Autism

The unique characteristics of children with autism lead to a variety of problems that they are more likely to exhibit in daily activities and academic tasks, such as inattention and inappropriate behaviors (Ivory, 2011). Among these problems, restrictive, repetitive behaviors are the main cause of distraction for children with autism, and these problems lead to the inability of children with autism to actively participate in intervention training, which impacts the effectiveness of the intervention training (Ayres, 1972).

Children exhibit behavioral problems in the classroom that makes sitting and listening more difficult. Schilling and Schwartz (2004) argue that children with autism prefer dynamic patterns in the learning process rather than simply sitting and that intervention training should be conducted at home or in the classroom whenever possible in order to achieve optimal arousal in

the autistic brain. Research has shown that the proper use of teaching aids can increase student engagement in academic tasks and daily activities (Hemmingson & Borell, 2002). The importance of teaching aids in the process of intervention training for children with autism is evidenced by the fact that children with autism typically spend five hours in a chair during intervention training. Research has shown that children with autism are more likely to maintain concentration and emotional stability during the use of a teaching chair that is appropriate for them (Ivory, 2011).

It has also been shown that parental involvement in the intervention (e.g., at home) is important for the success of the intervention, meaning that the skills learned by the child can be further enhanced by the intervention at home (Zachor & Ben Itzchak, 2010) and that parental involvement can help expose the child to more skills in everyday life (Burrell & Borrego, 2012). The importance of teaching aids for children with autism is evidenced by the fact that they cannot be ignored, even when interventions are conducted at home.

2.6 The Concept of Products for Children with Autism

The concept behind specialty products for diagnosed children is to design teaching aids to help children with autism by taking into account the physical, psychological, perceptual, and behavioral characteristics of autistic children as well as the function and structure of furniture.

2.7 Market Research on Furniture for Children with Autism

Currently, products designed to help children with autism are divided into four main categories: (a) sensory integration, (b) cognitive learning, (c) physical training, and (d) emotional relaxation. These four categories of instructional products include a series of functional products for coordination of body movements, balance, social skills, cognitive skills, emotional relaxation, sensory perception, gross motor and fine motor training for children with autism, and these four

categories of instructional products are described below.

2.7.1 Types of Sensory Integration

Every child with autism has varying degrees of sensory integration deficits, which include sensory perception deficits (visual, tactile, gustatory, olfactory, auditory) and proprioceptive and vestibular deficits (coordination of limbs, balance). Behavioral problems resulting from sensory integration deficits in children with autism lead to a lack of engagement in interventions or daily activities (Tunstall, 2010).

To achieve optimal learning, children with autism need physical forms of assistance to achieve increased sensory integration to receive information from the outside world, thus increasing the brain's ability to awaken to control their behavior (Schilling & Schwartz, 2004). Research has shown that when children with autism receive adequate sensory stimulation, they will show positive attitudes toward daily activities and interventions (Bagatell et al., 2010).

In the current market, there are teaching aids for children with sensory perception and physical, sensory integration disorders to help children with autism, such as the balance ball chair, as shown in Figure 2.4, which has been shown to be effective in helping children with autism with sensory integration disorders. The balance ball chair was shown to be effective in helping autistic children with sensory integration disorders by enabling them to participate in the intervention more quietly and attentively in the chair (Tunstall, 2010). This is because children with autism are stimulating and awakening their brains through benign stereotypical behaviors, and research has shown that performing rhythmic activities on the balance ball chair can modulate the autistic child's own sensory input in order to maintain calmness and focus (Schilling et al., 2003). At the same time, the ball's bounciness can better help children with

autism stimulate their proprioceptive and vestibular systems, which can stimulate left and right brain development while maintaining relaxation (Kuhn & Lewis, 2013).

Figure 2.4 Balance Ball Chair (Balance Ball Chair, n.d.)

2.7.2 Types of Cognitive Learning

Cognitive learning products develop children's ability to think independently, process information, and express emotions through the interaction of objects, and effectively support and guide their cognitive styles, helping them to understand social relationships and social patterns.

Dsouza and Raman (2010) argue that play is more intuitive than language for children with autism and that a simple interaction brings more trust than words between individuals, so through play, children with autism can be helped to associate social interactions with happy emotions and thus gain positive learning attitudes. Research has proven that cognitive learning-type aids give children with autism a sense of control through cause-and-effect relationships between objects (Brok & Barakova, 2010). This sense encourages children to communicate with each other while engaging in sensory play. The multi-sensory feedback and cause-and-effect behaviors of toys motivate and enhance social interactions.

As shown in Figure 2.5, children with autism receive auditory, visual, and tactile feedback from the mini piano through motor triggers, which can be used to teach children with autism cognitive learning skills such as pattern perception and object association.

Figure 2.5 Mirari Pop! Pop! Piano (Mirari Pop! Pop! Piano, n.d.)

2.7.3 Types of Physical Training

In intervention schools, therapists need to plan a variety of programs for children with autism in order to achieve their overall development. Current physical education programs designed for children with autism are often based on Newell's Constraint Model, which he wrote about in his article "Motor Development in Children: Aspects of Coordination and Control." Newell (1986) argues that behavior is a fundamental personal response to a specific perception of a particular environment, so the behavior is generated based on three specific types of constraints: (a) individual constraints, (b) environmental constraints, and (c) task constraints. (a) Individual constraints refer to the autistic child's own physiological state, such as the inability to pass a balance beam, which is due to the autistic child's poor balance. (b) Environmental constraints refer to environmental factors that are the cause of encouraging or discouraging movement in children with autism, such as scene lighting and size. (c) Task constraints refer to

rules proposed by the therapist.

Physical education courses or games designed according to Newell's theory can improve the motor ability of children with autism, among which physical training aids can be targeted to train children's fine hand movements and gross motor movements of the legs to cultivate children's body balance and motor ability. As shown in Figure 2.6, the surface of such balance beams has various textures, which can be used by children for gross motor training in the process of playing. The process of gross motor training not only can improve body balance and motor ability but also can stimulate the soles of children's feet, increasing the input of tactile information.

Figure 2.6 Weplay Tactile Balance Path (Weplay Tactile Balance Path, n.d.)

2.7.4 Types of Emotional Relaxation

Children with autism often lack good social relationships due to the fact that they exhibit loss of emotional regulation and physical movement leading to frequent emotional anxiety, producing behavioral manifestations of fear and denial of contact. Emotional relaxation-type products can help them focus their sensory nerves and relieve tension and anxiety, allowing them to focus and calm down. Emotional relaxation type tools are generally designed based on the theory of deep stress therapy described in 4.7 (Grandin & Scariano, 1986), as shown in Figure

2.7. This Squeezy Canoe provides pressure and weight while also providing the deep stress input that children with autism need to help relax and self-regulate in order to improve their focus and attention to classroom tasks.

Figure 2.7 Sensory Pea Pod (Sensory Pea Pod, n.d.)

2.8 The Learning Environment for Autism

The physical environment is one of the necessary factors for therapists to consider in the learning process of children with autism. The environment has the ability to alter human emotions and can even change human productivity (Salingaros, 2017). For children with autism, the negative effects of the environment are threatening. Research has shown that children with autism will feel stressed by different sounds in a scene, or anxious because of light sources in the environment, or nervous about physical contact caused by a crowded environment (Fittipaldi-Wert & Mowling, 2009).

Hernandez found in his research that of all environmental features, lighting is considered one of the most influential features that can affect human temperament and behavior. Classroom environments, on the other hand, are generally rich in sound sources, brightly lit, and often crowded. In summary, classrooms for children with autism should be quiet, poorly lit, and

spacious, and such environmental changes can significantly reduce the occurrence of problem behaviors.

2.9 Color Analysis of Children's Furniture

The influence of color on emotion was first suggested in 1840 in Goethe's "Theory of Colors", in which he argued that warm and cool colors could alter human emotional responses. In fact, colors are essential to the human visual experience (Adams & Osgood, 1973).

Among the environmental features, the one that attracts the most attention is the color. Studies have shown that color enhances attention and interest in treating objects in autistic individuals (Wichmann et al., 2002). Turner (1999) argued that for 85% of the eyes of autistic individuals color is more intense, while Kovattana and Kraemer (1974) found that children with autism are good at using color and size cues to categorize things. Brian et al. (2003) found that color had a positive effect on children with autism when they studied the condition, and they concluded that “in autism, stimulus features such as color may be encoded too readily, and thus are detected more easily than is typically the case” (p. 558).

In their study, Grandgeorge and Masataka (2016) found that children with autism were most inclined to the color red, followed by a preference for blue and green, with yellow being the most repulsive color. This is because the high brightness of yellow triggers a hypersensitive response in some children with autism. Geilman (2016) argued that clean and neutral colors are more acceptable to children with autism and emphasized that stress can be reduced through the application of colors. Heaton et al. (2007) found that children with autism may show a strong interest and obsession with objects of specific colors. On the other hand, children with autism may also experience aversion and anxiety due to the color of specific objects. To sum up, the scientific use of color can have a positive impact on the learning and life of children with autism.

Different, appropriate colors can alleviate their behavioral and psychological disorders.

2.10 Material Analysis of Children's Furniture

The surrounding sensory environment is very important because of the potential to induce high anxiety levels in children with autism (Gaines et al., 2016). Each person with autism experiences their environment in a different way. Tactile interactions under scientific research can help children with autism reduce behavioral problems such as anxiety and fear (Ahlquist, 2015).

Research has found that the sensory elements of autism are classified as hypersensitive or hypersensitive, with hyposensitivity referring to insufficient information received by the senses; hypersensitivity refers to an overload of information received by the senses (Geilman, 2016) For children with autism who are hypersensitive, they are more inclined to interact with textures because they are actively seeking certain stimuli to help the senses gather more information (Turner 2016). Seyedi (2019) believes that hypo-sensitive children can use heavier and rougher materials to improve the individual's experience. On the other hand, children with autism who are highly sensitive prefer soft natural materials (Geilman, 2016).

2.11 Sensory Design Theory

Children with autism experience sound, light and texture completely differently due to impairments in sensory integration. So seemingly innocuous design details may be a significant cause of stereotypical behavior and negative emotions in children with autism.

Magda Mostafa (2008) proposed a "sensory design matrix" (p. 203) that matches architectural elements to the sensory issues of autism, and after more than a decade of research and development, she proposed the world's first set of design guidelines for the autism community, called *An Architecture for Autism: Concepts of Design Intervention for the Autistic*

User, also known as the ASPECTSS Design Index. The design guidelines were developed to facilitate design for ASD and to provide ideas for sensory design that could be applied to autism. The design guidelines were developed to facilitate design for ASD and to provide ideas for sensory design that can be applied to autism.

By understanding the sensory integration deficits and special needs of children with autism and applying targeted design elements to favorably alter sensory input to children with autism, it is possible to help children with autism reduce challenging behaviors and create conditions conducive to increased learning for children with autism (Mostafa 2008). According to Mostafa (2008), experiments found that the application of an over-sensory design in the environment increased the attention duration of children with autism and reduced reaction time while also improving some of the challenging behaviors. According to Mostafa's (2008) questionnaire, 64% of the teachers believed that the most influential factor on autistic behavior was acoustics, 20% believed spatial sequencing, 8% believed lighting, 4% believed colors and patterns, and the last 4% believed texture (p. 198).

In addition, two findings were found through the experiment, the first being that the child's need to escape was reduced and they felt comfortable in this environment when he believed he had the option to exist to escape. This implies that children with autism need to have a certain safe distance established for them in their learning environment so that they have options that can protect them, and with options available to them, their need to escape is reduced and they feel comfortable. Another finding was the addition of dividers above the child's desk. When the child heard a sound or saw something moving around him, their attention was distracted by external factors, but they were unable to see above and around the dividers. At the

end of the experiment, the child changed the habit of looking up and distraction was reduced, thus becoming more focused (Mostafa 2008, p. 201).

Applying the concept of inclusive sensory design to furniture can cater to the special needs of children with autism to the extent possible. In this way, furniture can be made to help children with autism increase their attention as well as reduce challenging behaviors on a mental level.

Chapter 3 Design Guidelines

This design guideline is aiming at to provide suggestions for designing for sensory issues in children with autism. Sensory issues related to autism are very common, and most people with autism are affected by sensory issues. Small, seemingly insignificant things in life can lead to challenging behaviors in children with autism. Understanding how sensory integration deficits affect children with autism and designing specific conditions to reduce sensory overload or increase sensory input makes it possible to help reduce challenging behaviors and create conditions conducive to more effective learning for children with autism.

This approach can be divided into six steps: a) observation, b)identifying the sensory issues and sensory processing type of the child with autism through the checklist, further classifying the challenging behavior according to the characteristics of the sensory processing type if there is no challenging behavior observed by the designer in the checklist, c) determining which type of behavior the challenging behavior belongs to, d) determining the design principles, and e) analyzing which sensory system causes the behavior, and f) giving the final design recommendation.

Flow Chart of the Design Guideline

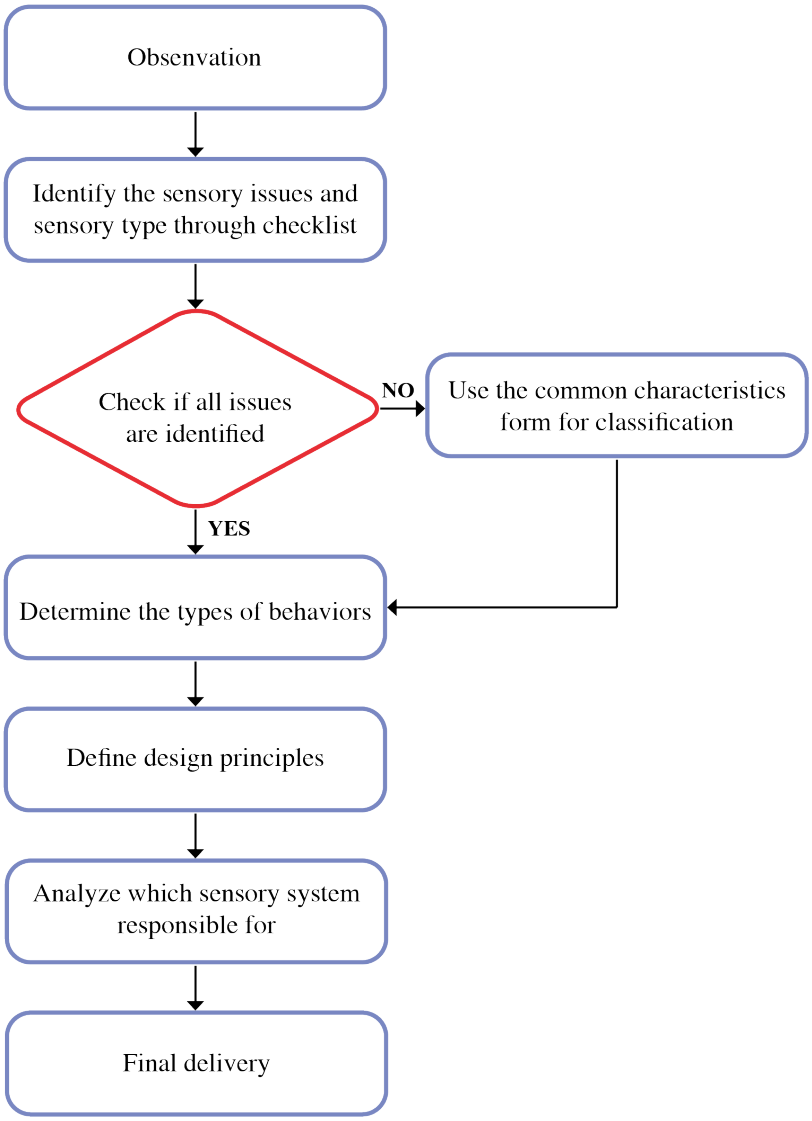

Figure 3. 1 Flow Chart of the Design Guideline

3.1 Identify

Due to the unique nature of autism, it is difficult to truly understand the child's needs through communication and other means. Designers may also not fully understand the various conditions of autism. The sensory processing patterns of children with autism are classified into four categories: sensation avoiding, low registration, sensation seeking, and sensation sensitivity (Dunn, 2001), each of which has its own characteristics. Some minor symptoms of sensory problems may be more difficult to notice.

With Table 3.1, this checklist includes the reactions and preferences of a child with autism when faced with various types of stimuli. The designer can check off the challenging behaviors he or she has learned about the child with autism through observation. If two or more challenging behaviors appear in the same vertical column, the child's sensory processing pattern can be identified. After the identified challenging behaviors and sensory processing patterns have been screened, the behavior patterns of children with autism can be further identified based on the different sensory processing patterns.

Checklist for Sensory issues

Sensation Avoiding (hyper)		Sensation Seeking (hypo)		Sensory Sensitivity (Passive)		Low Registration (Passive)	
Being angry at sudden noises	●	Craves certain foods	●	Difficulty finding small things	●	Doesn't mind or notice smells	●
Covering ears or hiding in social situations	●	Enjoy eating strongly flavored food	●	Confuses the letters	●	Doesn't mind or notice bright lights	●
Voiding everyday noises	●	Licks or tastes inedible objects	●	Runs hands through certain textures	●	Visual motor tasks apear mistakes	●
Distressed by high-pitched noises	●	Bites frequently	●	Confuses the sound of words	●	Can't tell good or bad visually	●
Avoids certain textures of foods	●	Make loud noises in a quiet environment	●	Get distracted by small noise	●	Difficulty finding objects in small area	●
Gags, chokes, or drools	●	Enjoy noises	●	Poor ability to adjust the volume of voice	●	Doesn't mind or notice tastes	●
Avoids mushy foods	●	Seems to be calmed by noise	●	Falls or bumps	●	Runs or walks slowly	●
Difficult to try new foods	●	Speak loudly	●	Doesn't know how much force should use	●	Does not get dizzy	●
Squints, or screens out sights	●	Moves and shakes head during writing	●	Poor posture	●	Difficulty maintaining upright posture	●
Scared of moving objects	●	Stares at bright lights	●	Trips	●	Prefer sleeping with heavy blankets	●
Avoids bright lights	●	Difficulty focusing on stationary objects	●	Doesn't eat if food mixed	●	Use excessive force when using objects	●
Avoids direct eye contact	●	Obsession with detailing	●	Doesn't like if smell mixed	●	Sits in one position for a long time	●
Becomes depressed around certain smells	●	Enjoys strong scents	●	Uncomfortable by moving objects	●	Seems inaudible noise	●
Avoiding public places	●	Fails to notice dangerous smells	●	Difficulty paying attention	●	Poor registration of sound input.	●
Dislike being close to other people	●	Smells objects constantly	●			Does not respond being called	●
Avoid of familiar foods due to smells	●	Exhibits trouble identifying smells	●			Unaware of being touched	●
Appears lazy	●	Runs into objects	●			Does not notice the mess	●
Seems uncoordinated	●	Stomps or walks loudly	●				
Avoids active activities	●	Rocks body back and forth	●				
Poor sense of direction	●	Chews objects	●				
Scared of movement activities	●	Prefers tight clothing	●				
Tends to appear clumsy or uncoordinated	●	Plays aggressively with other children	●				
Dislikes being turned upside down	●	Constantly touches things around them	●				
Seems stubborn	●	Craves vibrations	●				
Avoids certain textures or clothing	●	Prefers to be upside down	●				
Avoids hugs or physical contact	●	Seems unable to sit still	●				
Fear of large crowds	●	Rocking, swinging, or spinning constantly	●				
Refuses to walk barefoot	●	Seems very impulsive	●				
Avoids messy	●						

Table 3.1 Checklist for Sensory issues

Adapted from Dunn (1997; 2007) and Abraham et al. (2015)

3.2 Classification

Although there are only four sensory processing modalities, each child's sensory processing will manifest differently due to individual factors (Dunn, 2007). Therefore, the checklist in 3.2 may not be complete, and if the designer observes behaviors that do not appear in the table above, the sensory processing types of children with autism need to be classified according to the common characteristics of each sensory processing type in Table 3.2.

Sensory processing responses in ASD	
	Common characteristics
Sensation Avoiding (hyper)	Likes to repeat familiar behaviors
	Difficult to engage in new experiences
	Actively and quickly move away from the stimulus
	Higherlevels of anxiety
	Increased isolation
	Prefer quiet places
	Isolating and avoiding behaviors
	Stubbornness
	Ordering behaviors
Sensation Seeking (hypo)	Increased movement
	Touching objects
	Decreased safety awareness
	Increased excitability
	Inattention
Sensory Sensitivity (Passive)	Not interact with environment
	More irritable
	Notice more details and small changes
	Easily distracted by the environment, even minor changes
	Easily startled by things that appear out of nowhere
	Protest against uncomfortable things
Low Registration (Passive)	Unresponsive
	Wander
	Rarely participates
	Requires extra motivation
	Shows little interest in surroundings

Table 3.2 Sensory processing responses in ASD

Adapted from Dunn (1997; 2007) and Thompson & Raisor (2013)

3.2.1 Sensation Avoiding

According to Chapter 2, children with a sensory processing pattern of sensory avoiding, also known as hypersensitivity, present a positive attitude when confronted with a stimulus and quickly escape from it (Dunn, 2007). The common behavioral characteristics of children with this sensory processing type are often characterized by a preference for quiet places, a greater tendency to be anxious than other types of children, frequent avoidance, a dislike of new activities, and a consistent and strict adherence to a sequence of familiar activities, a predictable feeling that provides them with a degree of security (Dunn, 2007).

3.2.2 Sensation Seeking

According to Chapter 2, children with a sensory processing pattern of sensation seeking, also known as hyposensitivity, also show an active attitude and react to their environment when faced with new situations, trying to obtain enough sensory stimulation to increase the necessary sensory input to maintain an optimal state of arousal (Dunn, 2007). Common behavioral characteristics of children with this sensory processing type often include a tendency to walk or run, to touch new things frequently, to perform dangerous actions such as hanging upside down from a swing, and to appear hyperactive and inattentive in the classroom (Dunn, 2007).

3.2.3 Sensation Sensitivity

According to Chapter 2, children with a sensory processing pattern of sensory sensitivity respond more passively to new stimuli and are very sensitive and alert to sensory stimuli, but usually do not interact with them (Dunn, 2007). The common behavioral characteristics of children with this sensory processing type are usually irritability, e.g., children with autism may react very strongly (screaming or crying) to an unintentional touch from a partner, but this behavioral response is also based on the child's individual tendencies, and if the child does not

have an aversion to the stimulus, he or she may not react to it. In addition, this type of child is easily distracted by small sounds or objects and is sensitive to changes in the details of things (Dunn, 2007).

3.2.4 Low Registration

According to Chapter 2, children with a sensory processing pattern of Low Registration are also more passive in their responses to new stimuli, and in contrast to sensory sensitivity to sensory stimuli, children with autism in this row are barely aware of sensory stimuli in their environment and do not even tend to seek them out. (Dunn, 2007). Common behavioral characteristics of children with this sensory processing type are usually unresponsive, even to touch, may seem uninterested in what is going on around them, and often stand in the corner during group activities with no desire to participate.

Challenging behavior	Sensory processing pattern	Type of behavior	Sensory systerm	Input mode

Table 3.3 Challenging Behavior Analysis Form

The designer needs to write the observed challenging behavior in Table 3.3 and analyze the sensory processing pattern of the behavior through Table 3.1 or Table 3.2. The blue part means ignore the last two columns for now. After completing the table, the next step can be taken.

3.3 Types of Behavior

Determining the type of challenging behavior is an essential step for this design guide. The sensory processing type and stimulus characteristics are related to the specific behavior type, and the characteristics of each sensory processing type in Table 3.2 can determine which challenging behaviors are included in that sensory processing type. Figure 3.2 illustrates that there are five categories of challenging behaviors for children with autism: a) Externalizing behavior (Mangeot et al., 2001), b) Internalizing behavior (Merrell, 2008), c) Difficulties in emotional and attention regulation (Ruff & Rothbart, 2001; Bodrova & Leong, 2005), d) Restrictive repetitive behaviors (Turner, 1999), and e) Difficulties in daily life (Dunn, 2007). The following section explains in detail the characteristics and hazards of each type of challenging behavior and how to classify the behavior.

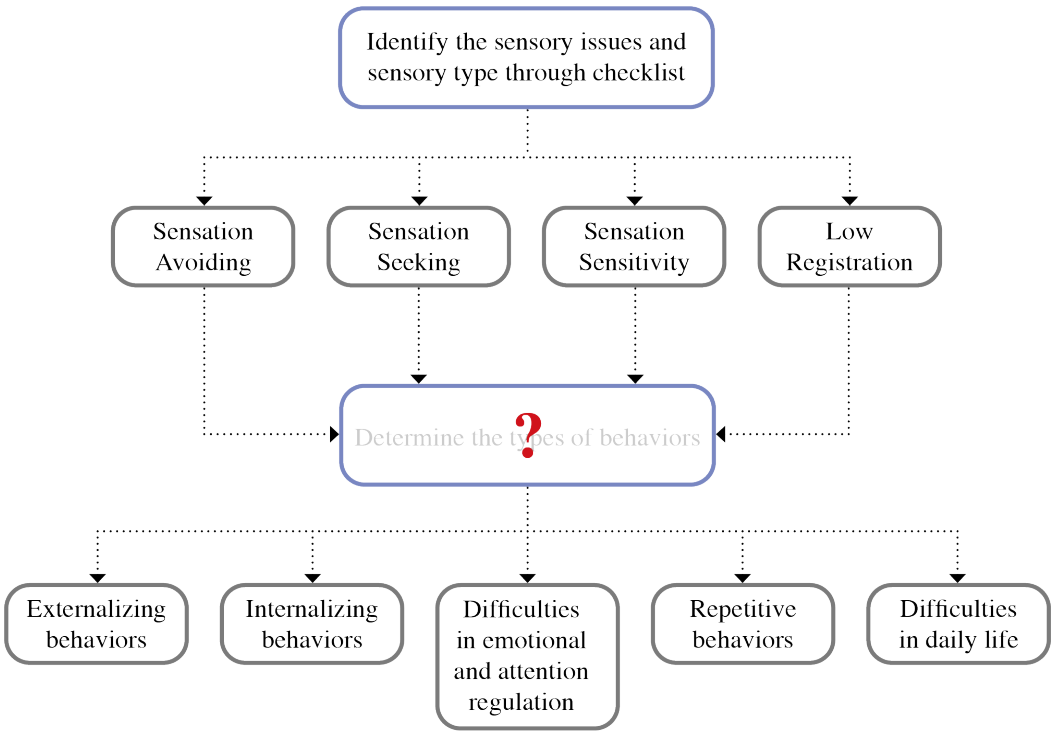

Figure 3. 2 Determine the types of behaviors

3.3.1 Externalizing Behavior

Problems with externalizing behaviors refer to a) aggressive behaviors in children, such as biting or hitting, and b) destructive behaviors, such as tantrums or disobeying instructions (Mangeot et al., 2001), where aggressive behaviors in children with autism may be at times appropriate and self-protective or destructive of the self and others (Ferris & Grisso 1998). These problem behaviors not only interfere with the child's daily functioning, but also exacerbate parental stress outside of the core symptoms of ASD and the difficulty of intervention treatment (Estes et al., 2013).

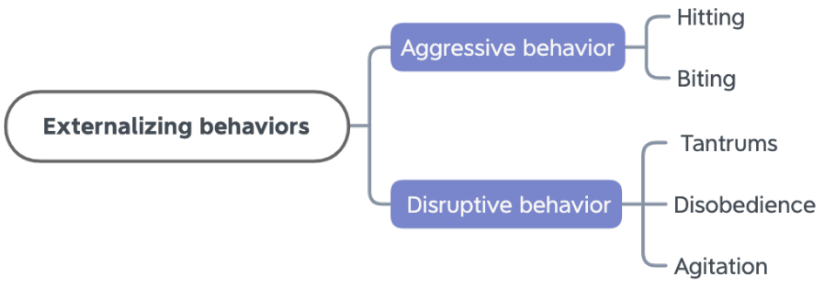

Figure 3. 3 Externalizing behavior

3.3.2 Internalizing Behavior

Anxiety and depression are the two most common internalizing disorders in children, and in addition to anxiety and depression, internalizing behaviors may also manifest as withdrawal (Merrell, 2008). As shown in Figure 3.4, anxiety manifests specifically as fear or numbness, depression as loss of interest in things or crying, and withdrawal as fatigue or irritability. These problem behaviors predict social difficulties in children with autism.

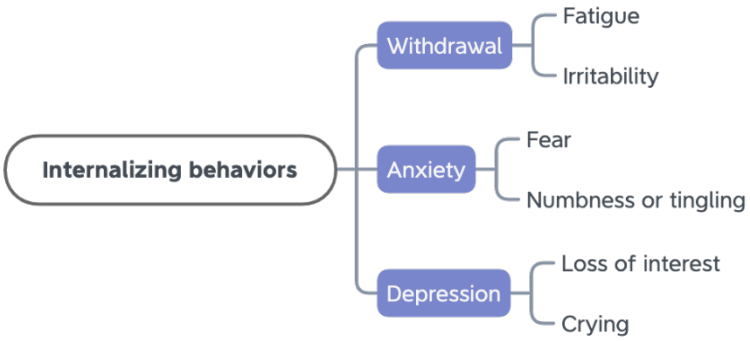

Figure 3. 4 Internalizing behavior

3.3.3 Difficulties in Emotional and Attention Regulation

According to what is mentioned in Chapter 2, attentional regulation refers to one's ability to deploy attention, which includes maintaining attention or ignoring irrelevant stimuli (Ruff & Rothbart, 2001). As shown in Figure 3.5, attentional deficits in children with autism are divided into inattention and hyperfocus, with inattention in children with autism resulting in low accuracy and poor performance on individual tasks (Davis et al., 2004), and hyperfocus as evidenced by restricted interest and unresponsiveness to calls. These problem behaviors not only interfere with the learning development of children with autism, but also lead to severe limitations in the future development of children with autism.

Self-regulation is "the capacity to control one's impulses both to stop doing something (even if one wants to continue doing it)" (Bodrova & Leong, 2005, p. 32). Deficits in self-emotional regulation are specific to impulsive behavior and hyperactivity, with impulsive behavior being specific to difficulty controlling emotions and self-management, and according to what is mentioned in Chapter 2, children with autism have difficulty expressing emotions correctly and lack empathy (Hobson, 2014). Hyperactivity is specifically manifested by a large increase in movement as well as an increase in arousal.

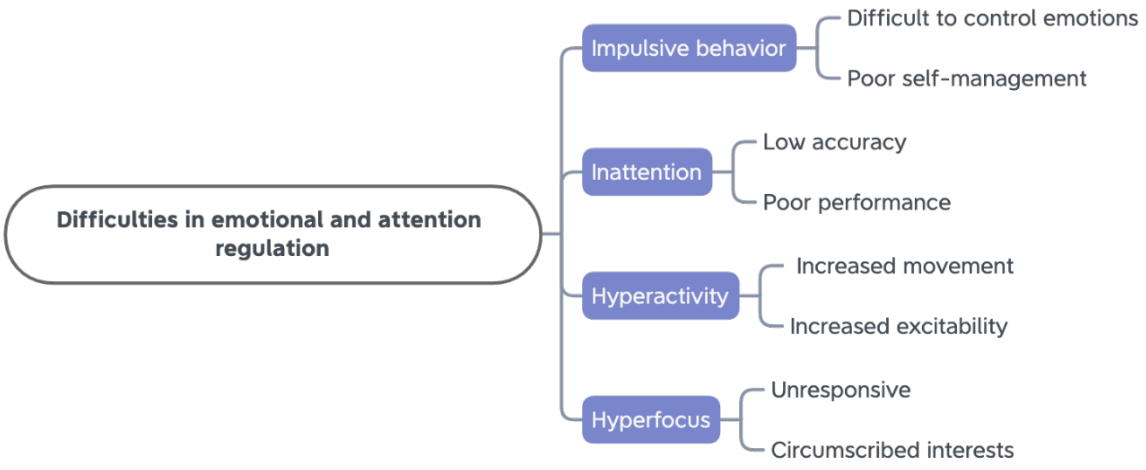

Figure 3. 5 Difficulties in emotional and attention regulation

3.3.4 Restrictive Repetitive Behaviors

Based on Chapter 2, Restrictive, repetitive behaviors are repetitive, irregular behaviors or actions that have no clear purpose or function (Turner, 1999). As shown in Figure 3.6, repetitive behaviors can be classified as restlessness and boredom, and many children with autism, who overreact to sensory input, have repetitive behaviors that help them block unwanted sensory input. These repetitive behaviors provide predictable and enjoyable information input for these sensitive children, and in addition for children who are not responsive to sensory input, they need repetitive behaviors to increase the necessary sensory input to maintain optimal arousal and to actively participate in daily activities.

Figure 3. 6 Restrictive repetitive behaviors

3.3.5 Difficulties in Daily Life

Difficulties in daily living are often due to a lack of self-care in children with autism (as shown in Figure 3.7), and children with autism can have varying degrees of difficulty eating and dressing, problem behaviors that severely interfere with the ability to perform daily living tasks (Dunn, 2007). However, since the purpose of this design guide is to apply design elements derived from surveys and research to large products such as furniture, the problems faced by this type of problem behavior are outside the scope of this study, so the following sections will not give design solutions for this type of behavior.

Figure 3. 7 Difficulties in daily life

3.3.6 Distinguish Challenging Behaviors for Each Sensory Processing Pattern

The reason children with autism engage in these challenging behaviors is that "these behaviors are inherently reinforcing by providing tactile, proprioceptive, and sensory stimulation to an extent, which is not achieved through conventional adaptive behavior" (Smith et al., 2005, p. 419). After understanding the detailed classification of each challenging behavior, using the characteristics of the four sensory processing patterns corresponding to the specific manifestations of all behaviors, it is clear what challenging behaviors are available for the different sensory processing pattern, and only after identifying the challenging behavior types can the guidelines give different design principles for the different behavior types.

3.3.6.1 Sensation Avoiding

The emotional responses associated with sensory avoiding are usually hostile and disobedient behaviors, or anxious and withdrawn behaviors when children with autism are confronted with excessive new stimuli (Dellapiazza et al., 2020). This type of children, since most are relatively stubborn, develop circumscribed interests, corresponding to specific manifestations of hyperfocus (Dunn, 2007), and the reason they perform repetitive behavior is to help them block unwanted sensory input. Jasmin et al. (2009) argued that sensory avoiding children have relatively low adaptive functioning. Adaptive functioning corresponds to a lack of self-care.

3.3.6.2 Sensation Seeking

The emotional responses associated with sensory seeking tend to actively engage their environment in the form of aggressive and rule-breaking behaviors (Dunn, 2001), and researchers have found that children with a sensory seeking pattern tend to exhibit reduced empathy and have more difficulty regulating social interactions (Mangeot et al., 2001). The reason they perform repetitive actions is to increase the necessary sensory input to maintain optimal arousal. Liss et al. (2006) after a study found that this type of child has relatively low autonomy skills, which refers to the ability to self-manage and to do things alone. In sensory seekers, attention is characterized by inattention, poor impulse control, and hyperactivity.

3.3.6.3 Sensation Sensitivity

The emotional responses associated with sensation sensitivity are typically depression and anxiety (Engel-Yeger et al., 2018). Children with sensation sensitivity are alert to stimuli, but they usually do not act on this stimulus (Dunn 1997; Dunn, 2007). Therefore, for the most part, sensation sensitive children do not engage in aggressive and disobedient behaviors;

however, when aversive stimuli are present, this type of child experiences disobedience, screaming, and mood changes (Dunn, 1997; Dunn, 2007). Alternatively, they perform repetitive actions to block the input of aversive stimuli. Because children with this type of autism tend to be attracted to small sounds in their environment, their attention is often distracted. Their characteristics will often protest uncomfortable things, so eating and dressing are also very difficult for them.

3.3.6.4 Low Registration

The emotional responses associated with low registration are roughly the same as sensory sensitivity, which is also depression and anxiety (Engel-Yeger et al., 2018). They often ignore instructions, which appear flat because they are overly focused (Dunn, 1997; Dunn, 2007). The reason they perform repetitive actions is to increase the necessary sensory input.

3.3.7 Behavior Classification Chart

Table 3.4 provides a clear picture of the challenging behaviors that arise from each sensory processing pattern, and in the next steps, the guide will give targeted design principles to help with the different types of challenging behaviors.

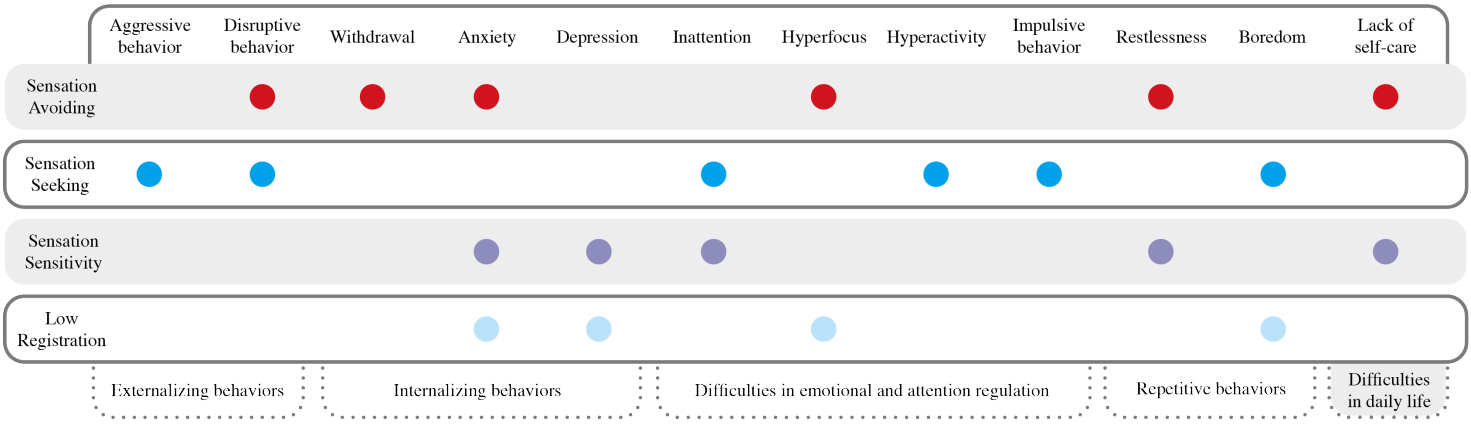

Table 3.4 Behavior Classification Chart

3.4 Define

In the above steps, the designer can identify the observed sensory processing patterns of the child with autism as well as the challenging behaviors, and next, it is necessary to define the resolution of the different sensory processing patterns from the challenging behaviors.

3.4.1 Aggressive Behavior

Aggressive behavior has been defined as behavior motivated by anger that leads to hostile or violent behavior (Rosenzweig, 1977), and for children with autism, the environment and physiology have a very important influence on aggressive behavior. The reasons that trigger the aggressive behavior in autistic children are a) difficulty in understanding what is happening around them, b) the desire to express their needs or pain, and c) sensory needs for stimulation (Dunn, 2001).

Sensation Seeking: The approach to mitigating aggressive behavior should be to guide the child to express his or her emotions in a more positive way and avoid aversive sensory stimulus input (Dunn, 1997; Dunn, 2007), using a balanced sensory input to help distract the child and reduce aggressive behavior.

3.4.2 Disruptive Behavior

Disruptive behavior refers to behaviors that violate social norms when children have difficulty controlling their behavior (APA, 2013). The causes of disruptive behavior are a) to obtain restricted and repetitive behaviors, and b) to avoid uncomfortable social and sensory demands (Reese et al., 2005).

Sensation Avoiding: Disruptive behavior should be mitigated by helping the child reduce the sensory stimuli that lead to challenging behavior (Mangeot et al., 2001).

Sensation Seeking: Disruptive behavior should be alleviated by giving the child the sensory stimulation he or she wants (Dunn,2001).

3.4.3 Withdrawal

Withdrawal behavior is defined as a disengagement behavior that a person engages in when he or she is physically and/or psychologically stressed. (Pinder, 2008). Causes of withdrawal are a) unexpected changes in plans or routines (Thompson & Raisor, 2013), and b) sensory overload (Dunn, 2001).

Sensation Avoiding: Reducing or modifying sensory stimuli helps children with autism to be more receptive, using sensory input to create positive emotional memories (Arsenault, 2020)

3.4.4 Anxiety

Anxiety is defined as "an emotion characterized by feelings of tension, worried thoughts and physical changes like increased blood pressure" (APA, 2013). Causes of anxiety are a) prevention or disruption of repetitive behaviors (Howlin, 1997; 1998), and b) sensory overload (Dunn, 2001).

Sensation Avoiding: Reduce sensory input and prevent negative emotions caused by excessive sensory input.

Sensation Sensitivity: Reduce sensory input and allow the child to protect against sensory overload in his or her own way (Ferris & Grisso， 1998).

Low Registration: By analyzing the sensory input needed for the child's repetitive behavior, it helps translate into effective positive sensory input.

3.4.5 Depression

Depression is defined as “a common and serious medical illness that negatively affects how you feel, the way you think and how you act.” (APA, 2013). The causes of depression are a)

repeated thinking about negative events and emotions (Barhill & Smith, 2001), b) environment becomes unpredictable and disrupts the laws followed, and c) failed interaction attempts and inability to succeed (Ozonoffet et al., 2002).

Sensation Sensitivity: Avoid repeated thoughts of negative effects and balance aversive stimuli with positive sensory input (Dunn, 1997; Dunn, 2007).

Low Registration: Actively expand new interests and divert attention to balance the negative effects (Dunn, 1997; Dunn, 2007).

3.4.6 Inattention

Inattention is defined as "a state in which there is a lack of concentrated or focused attention or in which attention drifts back and forth" (APA, 2013). The causes of inattention are a) Outside stimulation.

Sensation Seeking: Avoiding external stimuli to the child by reducing the input of sensory information leads to distraction (Mostafa 2008).

Sensation Sensitivity: Reducing the input of sensory information can help keep focus (Mostafa 2008).

3.4.7 Hyperfocus

Hyperfocus is defined as "a phenomenon that reflects one's complete absorption in a task, to a point where a person appears to completely ignore or 'tune out' everything else." (Ashinoff & Abu-Akel, 2019). The causes of hyperfocus are a) passionate pursuit of interests, b) sensory overload (Dunn, 2001), and c) processing of emotions through the intellect and inability to feel them (Rowland, 2020)

Sensation Avoiding: Hyperfocus due to sensory overload, which should reduce sensory input.

Low Registration: Changing restricted interests, shifting and distracting over-focused attention to new stimuli.

3.4.8 Hyperactivity

Hyperactivity is defined as “excess movement that is not fitting to the setting.” (APA, 2013). The cause of hyperactivity is a) environmental factors.

Sensation Seeking: Some factors in the environment can cause distraction and irritability, which can lead to hyperactivity in children. Reducing external information input can reduce hyperactivity in children (Dunn, 2007).

3.4.9 Impulsive Behavior

Impulsive behavior is defined as “hasty acts that occur in the moment without thought.” (APA, 2013). The causes of impulsive behavior are usually related to executive dysfunction, and when executive dysfunction occurs, the child's psyche becomes frustrated and angry (Fitzpatrick et al., 2016).

Sensation Seeking: Positively expand and encourage the input of new sensory information to balance negative emotions (Dunn, 2007).

3.4.10 Restlessness

Repetitive behaviors due to restlessness are caused by an overload of sensory information input in children with autism (Turner, 1999). The reason they perform repetitive actions is to help them block unwanted sensory input.

Sensation Avoiding: Reasonably direct and increase the sensory input needed to calm the child (Dunn, 2001).

Sensation Sensitivity: Engaging in repetitive behaviors can help overcome psychological uneasiness (Dunn, 2001).

3.4.11 Boredom

Repetitive behaviors due to boredom result from the low sensory information input and the need to express what they do in children with autism (Turner, 1999). The reason they perform repetitive actions is to increase the necessary sensory input.

Sensation Seeking: Properly guided repetitive behaviors can help children stimulate their sensory systems and get enough sensory information to maintain optimal arousal (Dunn, 2001).

Low Registration: The more sensory system input obtained by eliciting repetitive behaviors, the more receptive and responsive the child will be (Bodrova & Leong, 2005).

In summary, this step summarizes the information input required by the four sensory processing patterns for different challenging behaviors with the aim of helping children with autism to reduce challenging behaviors. Based on the observed challenging behaviors and corresponding to Table 3.5, the designer will be able to find the information input required to mitigate the different types of challenging behaviors in a more targeted manner. Next, the design guide will categorize each challenging behavior according to the sensory system. This will help designers to apply the corresponding information input to each sensory system.

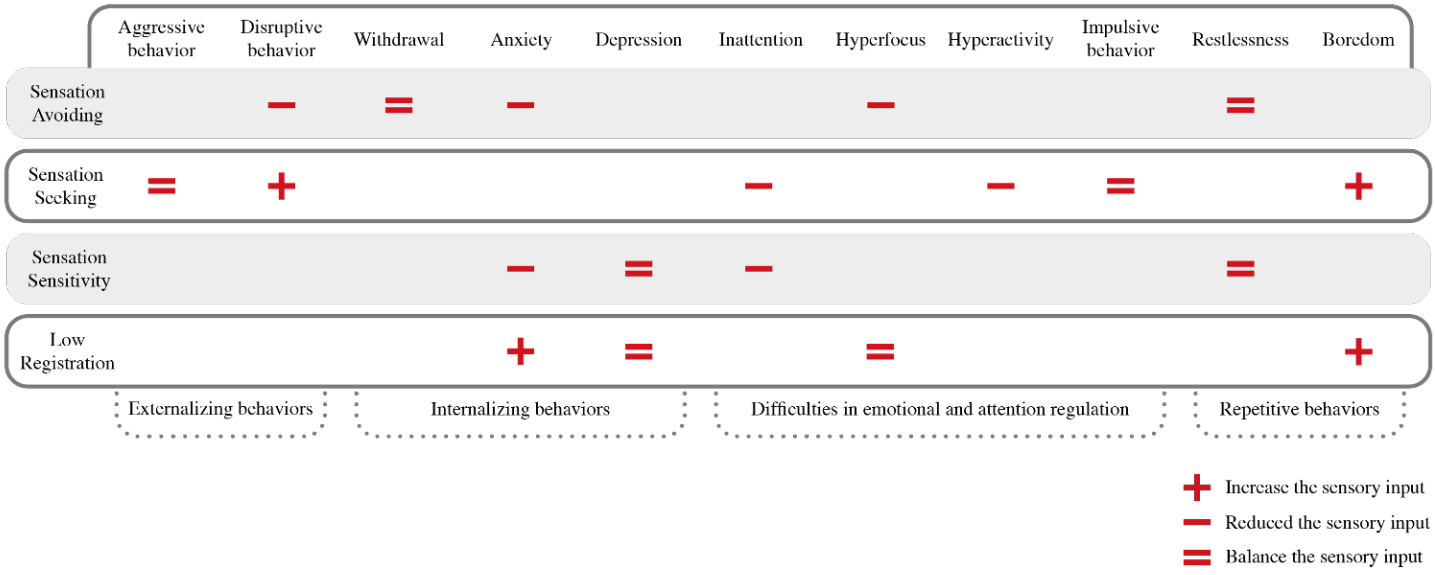

Table 3.5 Mode of Sensory Input

3.5 Analyze

In this step, the designer will classify the sensory systems according to their characteristics corresponding to specific challenging behaviors and determine the sensory systems that cause such behaviors by analyzing the challenging behaviors.

3.5.1 Sound/Auditory

Based on the information in Chapter 2, the auditory system is the system that helps humans receive and process information from the ear. Children with a healthy auditory system can respond naturally to sounds and can identify directions by sounds as well as filter out everyday noise. Most children are not distracted by ordinary sounds. Children with autism have two types of auditory system problems: a) hypersensitive to auditory input (Hutt et al., 1964) and b) hyposensitive to auditory input (Rimland, 1964). Type A children are overwhelmed by even normal volume input and may develop challenging behaviors such as anxiety, withdrawal, and

hyperactivity. Type B children are unable to recognize normal volume input. It appears as if they cannot hear sounds and will not respond to them.

3.5.2 Touch/Tactile

Based on the information in Chapter 2, the tactile system is the system that helps humans obtain information from the skin. Tactile sensations can be linked to memory, and happy or unhappy memories can be associated with certain tactile sensations. Children with a healthy tactile system can better organize tactile information input and are not distracted by small tactile inputs. Children with autism have two types of tactile system problems: a) hypersensitive to touch (Hutt et al., 1964) and b) hyposensitive to touch (Rimland, 1964). Type A children are overwhelmed by normal tactile input and develop many challenging behaviors. Type B children have less tactile information input, prefer touch and want more tactile input.

3.5.3 Taste/ Oral

Based on the information in Chapter 2, the oral system is the system that helps humans process information input from the mouth (Simon et al, 2006). Information includes temperature, texture, and taste. Children with autism have two types of problems with the oral system: a) hypersensitive to oral input and b) hyposensitive to oral input. Type A children are mostly picky eaters and have specific eating habits, such as using only specific utensils and eating only characteristic foods (Lane et al, 2014), while type B children may have behaviors such as biting or eating inedible items to help them provide more input. These behaviors are intended to help them provide more input to maintain attention and their own behavior. Design principles related to the oral system cannot be applied to the furniture, so this thesis will not provide a design approach to promote oral systems.

3.5.4 Sight/Visual

Based on the information in Chapter 2, the visual system is the system that helps humans receive information through the eyes. Children with a healthy vestibular sense are better able to see details in their environment. The problematic presentation of the visual system in children with autism is divided into two types: a) hyper-sensitive to vision (Hutt et al., 1964) and b) hyposensitive to vision (Rimland, 1964). Type A children's vision is distracted by the large amount of visual information brought by the environment and cannot focus, and type B children become hyperfocused by gazing at the same details for a long time.

3.5.5 Smell/Olfactory

Based on the information in Chapter 2, the olfactory system is the system that helps humans to obtain information about the odors around them, the neural pathways collect the information and transmit it to the brain, and children with a healthy olfactory system have the ability to perceive odors and their characteristics and also to distinguish between different odors (Rabin, 1988; Stockhorst & Pietrowsky, 2004). In contrast, the problematic manifestations of the olfactory system in children with autism are classified into two types: a) hypersensitive to odors (Hutt et al., 1964), and b) hyposensitive to odors (Rimland, 1964). Type A children may produce vomiting, or refuse to eat, even when confronted with ordinary odors. Type B children may try to smell strongly smelling objects, which may lead to safety problems. However, since odor-related design principles may not be applied to the products relevant to this thesis, no design principle will be given for the olfactory system.

3.5.6 Proprioceptive

Based on the information in Chapter 2, proprioception is defined as " traceable to actions of the organism itself" (Sherrington, 1952). The proprioception helps humans to maintain

coordinated movement, and children with healthy proprioception can use pencils with just the right amount of force. Children with autism have two types of proprioceptive problems, both requiring increased proprioceptive input; Type A children have difficulty grading the strength of their movements (Lane et al, 2014), and type B children do not have good control of their bodies (Travers, et al, 2013).

3.5.7 Vestibular

Based on the information in Chapter 2, the vestibular sense is responsible for providing the brain with information about spatial orientation (Ewald, 1892). Children with a healthy vestibular sense are better able to maintain balance and movement. Children with autism have two types of vestibular sensory problems: a) hypersensitivity to movement and b) hyposensitivity to movement. Type A children need constant movement to feel satisfied and type B children are uncoordinated and awkward in movement.

3.5.8 The Media of Sensory System

Table 3.6 summarizes the media of each sensory system and the way in which information is entered. The designer can correspond the observed challenging behaviors to the chart and will know which sensory system of the observed child with autism is out of order.

Sensory systerm		
	Media	Input method
Auditory	Sound	Daily noise, the sound of leaves, talking
Tactile	Touch	Clothing, texture, pain
Visual	Sight	Details, light, color, small things
Proprioceptive	Body position	Pushing, pulling, stomping, squeezing, jumping, bending
Vestibular	Movement	Spinning, turning, flipping, climbing

Table 3.6 List of sensory system

3.5.9 The Overall Form

After completing all of the above steps, the designer will need to fill out which sensory issue the child is impaired in (Table 3.7) and derive the type of information input needed for that sensory system based on Table 3.5. The input may not be identical because children with autism are not limited to one sensory processing mode and the child can exhibit different patterns for each type of sensory stimulation (Dunn, 2007); for example, a child may be hypersensitive to touch but require proprioceptive stimulation.

Challenging behavior	Sensory processing pattern	Type of behavior	Sensory systerm	Input mode

Table 3.7 Overall form

3.6 Final Delivery

At the end of this Chapter, sensory design guidelines are summarized for the auditory, tactile, visual, vestibular, and proprioceptive characteristics of children with autism. Children with autism are helped to meet their special needs by increasing sensory input, decreasing sensory input, and balancing sensory input. Designers will use the sensory design guidelines to create exclusive products for children with autism that are applicable to the individual and targeted to help children with autism improve their sensory issues.

3.6.1 Design Principle for Sound/Auditory

According to the design guidelines for auditory systems, if the child needs to reduce auditory input, the product as a whole need to avoid the use of movable parts because noise will be emitted during the movement of the parts. Also, Mvubu and Patnaik (2019) found that the reasonable use of acoustics can effectively reduce noise and provide sound absorption if there is an air gap in the product. The addition of dividing panels can also be effective in blocking the input of auditory.

Srithaneschai (2020) found that cylindrical rooms can be effective in increasing the input of auditory (Figure 3.8).

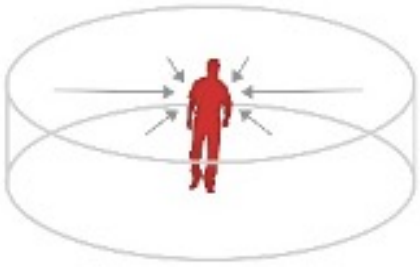

Figure 3.8 Acoustic Design 1 (Srithaneschai, 2020)

Dome cellings can also increase echoes (Figure 3.16). Pleated surfaces can prevent sound waves from bouncing, and conversely, smooth surfaces can promote sound wave bouncing (Brolin, 2010).

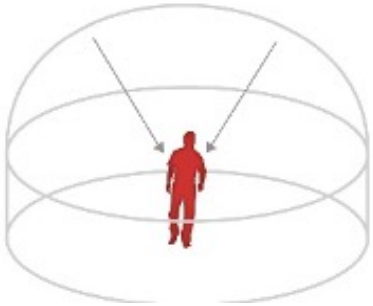

Figure 3.9 Acoustic Design 2 (Srithaneschai, 2020)

If it is needed to balance the sensory input, the designer must understand the observed child's aversive stimuli from the Overall form and reduce the sensory input of his aversive stimuli and increase the sensory input of his desired sensory system.

3.6.2 Design Principle for Touch/Tactile

Dunn (2007) suggested that continuous tactile input could improve attention in children with autism and adding raised bumps could provide continuous tactile input. Ayres (1979) found in a study that deep touch pressure could provide continuous tactile input and could calm children with autism psychologically and physically. Mostafa (2008) found that autistic children with tactile sensory sensitivities can only accept single sensory experiences, and that designers can provide different tactile experiences in order to increase tactile input.

3.6.3 Design Principle for Sight/Visual

Clean lines can reduce visual input for children with autism and complex lines can increase visual input. A more open space can help children with autism get more visual input, and conversely, if visual input needs to be reduced they need a more closed space. Grandgeorge and Masataka (2016) found that high brightness colors can increase visual input in children with autism, which would suggest that warm colors can increase visual input and cool colors can decrease visual input. Research has demonstrated that the judicious use of space can also help increase or decrease visual input in children with autism (Fittipaldi-Wert & Mowling, 2009) Differentiated spaces can help children with autism focus and increase visual input and uniform spaces can decrease visual input.

3.6.4 Design Principle for Proprioceptive

Using muscle movement to generate proprioceptive signals (Goodwin et al., 1972), it is important to add moving parts to design elements to help increase proprioceptive input.

Understanding and predicting limb movements can increase proprioceptive input (Proske & Gandevia, 2012), so designs that reflect their own function can increase proprioceptive input. Mostafa (2008) found that asymmetrical shapes increased proprioceptive input in children with autism, and conversely, symmetrical shapes decreased proprioceptive input.

3.6.5 Design Principle for Vestibular

Based on the previous information, any activity with a rhythmic pattern can help children with autism increase vestibular input, allowing them to be quieter and more attentive (Schilling et al., 2003). Examples include a swivel, rock and swing. If vestibular input needs to be reduced, the motor element can be reduced.

Conclusion

In summary, designers can use Table 3.8 to select the design elements needed to give physical forms of assistance to children with autism in the form of design to achieve the ability to increase sensory input and thus increase the brain's ability to awaken to control their behavior (Schilling & Schwartz, 2004).

Sensory Design Guidelines			
	+	-	=
Auditory	Use curved shape	Non-movable parts	A(-)+T(+)
	Low enclosure	Increasing the air gap	
	Use curved Top	Dividing panels	A(-)+Visual(+)
	Lower back	Use reverse curved shapes	
	Moveable parts	High enclosure	A(-)+P(+)
	Screening Panel	Higher back	A(-)+V(+)
	Flat	Fold	
Tactile	Provide pressure and weight	Alcoves (Hide space)	T(-)+A(+)
	Raised bumps	Smooth surface	T(-)+Visual(+)
	Smaller personal space	Larger personal space	T(-)+P(+)
	Multi-sensory experiences	Single sensory experience	T(-)+V(+)
Visual	Complex lines	Clean lines	Viusal(-)+A(+)
	Open space	Block visual distractions	Visual(-)+T(+)
	Warm colors	Cooler colors	Visual(-)+P(+)
	Differentiation	Harmonization of space	Visual(-)+V(+)
Proprioceptive	Asymmetrical structure	Symmetrical structure	P(-)+A(+)
			P(-)+T(+)
	Non-fixed elements	Fixed elements	P(-)+Visual(+)
			P(-)+V(+)
Vestibular	Swivelable	Robustness	V(-)+A(+)
	Swingable		V(-)+T(+)
			V(-)+Visual(+)
	Rockable		V(-)+P(+)

Table 3.8 Sensory Design Guidelines

Chapter 4 Design Application

In this chapter, an application of the design guidelines of Chapter 3 will be demonstrated by a hypothetical design project going through the flowchart in Figure 3.1.

4.1 Identify the Sensory Processing Pattern

First, the roles and characteristics of the children with autism applied in this chapter are fictitious due to the needs of the thesis, in order to verify the feasibility of this design guideline.

The observed child with autism was named Mike. Mike was observed to hate physical contact. The therapist asked the children to take off their shoes and play in the activity room, but Mike refused and kept hiding in the corner. Mike also seemed to be very sensitive to light. He always stood far away from the window and sometimes even covered his eyes when he passed by the window. During music lessons, Mike seemed very focused, but when the song ended, Mike would yell and scream for the song to be replayed. When walking, Mike would often bump into things (Figure 4.1).

Figure 4.1 Mike’s story

Using the checklist in 3.1, the corresponding behavior can be checked to find the type of sensory processing for each of Mike's sensory systems. From Table 4.1, it is found that Mike's sensory system has multiple sensory processing patterns, among which avoiding bright light and refusing to walk barefoot belongs to the behavior of sensory avoiding, and requesting to replay

the song belongs to the behavior of sensory seeking. Bumping into things frequently or falling down are behaviors of low registration.

Checklist for Sensory issues

Sensation Avoiding (hyper)		Sensation Seeking (hypo)		Sensory Sensitivity (Passive)		Low Registration (Passive)	
Being angry at sudden noises	○	Craves certain foods	○	Difficulty finding small things	○	Doesn't mind or notice smells	○
Covering ears or hiding in social situations	○	Enjoy eating strongly flavored food	○	Confuses the letters	○	Doesn't mind or notice bright lights	○
Voiding everyday noises	○	Licks or tastes inedible objects	○	Runs hands through certain textures	○	Visual motor tasks apear mistakes	○
Distressed by high-pitched noises	○	Bites frequently	○	Confuses the sound of words	○	Can't tell good or bad visually	○
Avoids certain textures of foods	○	Make loud noises in a quiet environment	○	Get distracted by small noise	○	Difficulty finding objects in small area	○
Gags, chokes, or drools	○	Enjoy noises	○	Poor ability to adjust the volume of voice	○	Doesn't mind or notice tastes	○
Avoids mushy foods	○	**Seems to be calmed by noise**	●	Falls or bumps	○	Runs or walks slowly	○
Difficult to try new foods	○	Speak loudly	○	Doesn't know how much force should use	○	Does not get dizzy	○
Squints, or screens out sights	○	Moves and shakes head during writing	○	Poor posture	○	Difficulty maintaining upright posture	○
Scared of moving objects	○	Stares at bright lights	○	Trips	○	Prefer sleeping with heavy blankets	○
Avoids bright lights	●	Difficulty focusing on stationary objects	○	Doesn't eat if food mixed	○	Use excessive force when using objects	○
Avoids direct eye contact	○	Obsession with detailing	○	Doesn't like if smell mixed	○	Sits in one position for a long time	○
Becomes depressed around certain smells	○	Enjoys strong scents	○	Uncomfortable by moving objects	○	Seems inaudible noise	○
Avoiding public places	○	Fails to notice dangerous smells	○	Difficulty paying attention	○	Poor registration of sound input.	○
Dislike being close to other people	○	Smells objects constantly	○			Does not respond being called	○
Avoid of familiar foods due to smells	○	Exhibits trouble identifying smells	○			Unaware of being touched	○
Appears lazy	○	Runs into objects	○			Does not notice the mess	○
Seems uncoordinated	○	Stomps or walks loudly	○			**Bumps a lot**	●
Avoids active activities	○	Rocks body back and forth	○				
Poor sense of direction	○	Chews objects	○				
Scared of movement activities	○	Prefers tight clothing	○				
Tends to appear clumsy or uncoordinated	○	Plays aggressively with other children	○				
Dislikes being turned upside down	○	Constantly touches things around them	○				
Seems stubborn	○	Craves vibrations	○				
Avoids certain textures or clothing	○	Prefers to be upside down	○				
Avoids hugs or physical contact	○	Seems unable to sit still	○				
Fear of large crowds	○	Rocking, swinging, or spinning constantly	○				
Refuses to walk barefoot	●	Seems very impulsive	○				
Avoids messy	○						

Table 4.1 Marked checklist for sensory issues

4.2 Determine the Type of Behavior

The analysis revealed that Mike's refusal to walk barefoot and disobeying the therapist's instructions belonged to disruptive behavior, sensitivity to light and wanting to stay away from the window belonged to withdrawal, asking the therapist to play music constantly and getting angry if it was not played belonged to disruptive behavior, and keeping falling but also continuing to try is because Mike's proprioceptive input is too little and leads to anxiety.

Challenging behavior	Sensory processing pattern	Type of behavior	Sensory systerm	Input mode
Refused to walk bare foot	Sensation Avoiding	Disruptive behavior		
Afraid of lights	Sensation Avoiding	Withdrawal		
Refused to stop play music	Sensation Seeking	Disruptive behavior		
Fear of fall	Low Registration	Anxiety		

Table 4.2 Filled Challenging Behavior Analysis Form

The designer should fill in Table 4.2 with the information obtained so far for challenging behavior and sensory processing patterns respectively. Once this chart is completed, then the designer should proceed to the next step.

4.3 Determine the Sensory Input

After obtaining information about Mike's challenging behavior and the corresponding sensory processing pattern, the required sensory input mode for Mike can be obtained according to Table 3.5 (Table 4.3). Disruptive behavior, in which the sensory processing pattern is sensory avoiding, requires helping Mike to reduce the sensory input that makes him feel uncomfortable. In the case of disruptive behavior where the sensory processing pattern is sensory seeking, it is necessary to increase the sensory input that Mike needs. Withdrawal, in the case of sensory

avoiding, helps Mike reduce the sensory input that makes him feel uncomfortable and increase the sensory input that he wants in order to shift negative emotions and balance sensory input. In the case of anxiety, where the sensory processing pattern is low registration, the sensory input required by Mike needs to be increased.

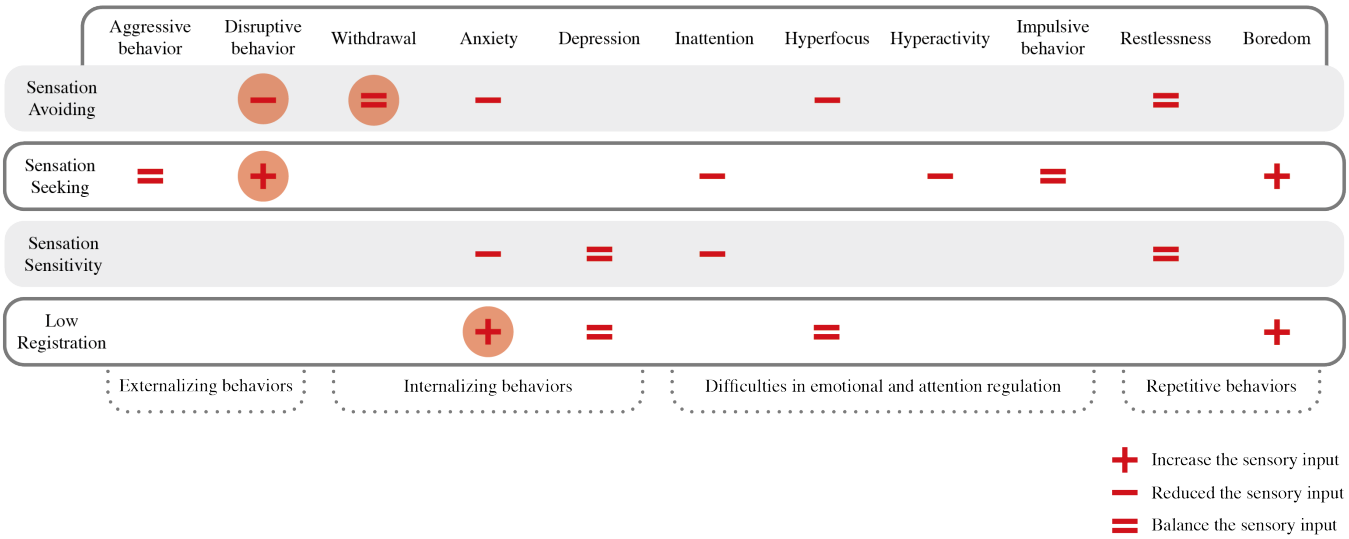

Table 4.3 Filled Mode of Sensory Input

4.4 Identify the Sensory System

In this step, the designer should identify which sensory system is causing Mike's challenging behavior based on Table 3.6. Mike's refusal to walk barefoot and his aversion to physical contact is caused by a tactile system impairment, Mike's request to listen to music all the time is caused by an auditory system impairment, Mike's sensitivity to light and his desire to stay away from windows is caused by a visual system impairment, and often Mike's frequent falls were caused by a proprioceptive impairment. Finally, the resulting sensory systems and the corresponding sensory input modes are filled in Table 4.4.

Challenging behavior	Sensory processing pattern	Type of behavior	Sensory systerm	Input mode
Refused to walk bare foot	Sensation Avoiding	Disruptive behavior	Tactile	−
Afraid of lights	Sensation Avoiding	Withdrawal	Visual	=
Refused to stop play music	Sensation Seeking	Disruptive behavior	Auditory	+
Fear of fall	Low Registration	Anxiety	Proprioceptive	+

Table 4.4 Filled Overall form 1

In this case, the sensory input mode required by Mike's visual system is balanced sensory input. Since Mike is sensitive to light, Mike needs to reduce the sensory input to the visual system as well as increase the proprioceptive input or auditory input to balance Mike's anxiety (Table 4.5).

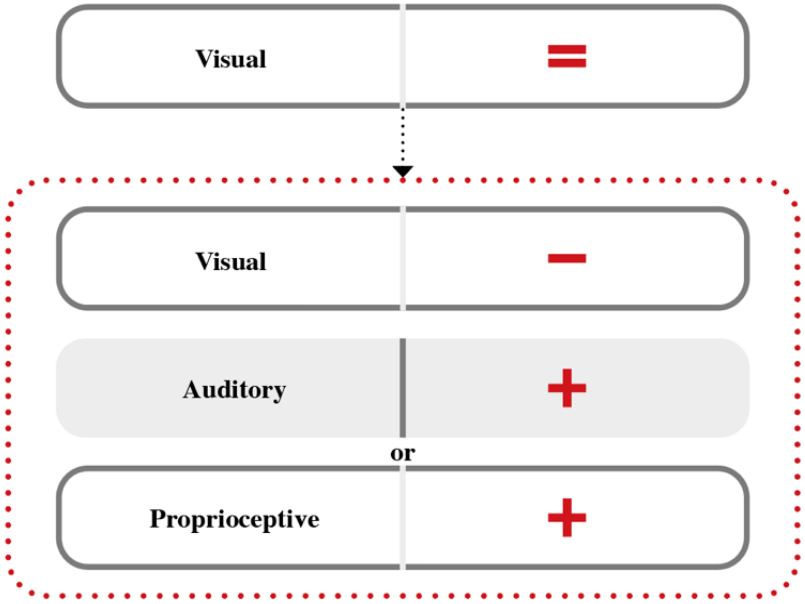

Table 4.5 Filled Overall form 2

4.5 Final Delivery

In the final step, the design elements that can effectively help Mike are selected based on the information in Table 4.4 and Table 4.5 (Shown in Table 4.6): Auditory needs to increase sensory input, tactile needs to reduce sensory input, visual needs to balance sensory input, and proprioceptive needs to increase sensory input.

Sensory Design Guidelines			
	+	-	=
Auditory	**Use curved shape**	Non-movable parts	A(-)+T(+)
	Low enclosure	Increasing the air gap	
	Use curved Top	Dividing panels	A(-)+Visual(+)
	Lower back	Use reverse curved shapes	
	Moveable parts	High enclosure	A(-)+P(+)
	Screening Panel	Higher back	A(-)+V(+)
	Flat	Fold	
Tactile	Provide pressure and weight	**Alcoves (Hide space)**	T(-)+A(+)
	Raised bumps	**Smooth surface**	T(-)+Visual(+)
	Smaller personal space	**Larger personal space**	T(-)+P(+)
	Multi-sensory experiences	**Single sensory experience**	T(-)+V(+)
Visual	Complex lines	Clean lines	**Viusal(-)+A(+)**
	Open space	Block visual distractions	Visual(-)+T(+)
	Warm colors	Cooler colors	**Visual(-)+P(+)**
	Differentiation	Harmonization of space	Visual(-)+V(+)
Proprioceptive	**Asymmetrical structure**	Symmetrical structure	P(-)+A(+)
			P(-)+T(+)
	Non-fixed elements	Fixed elements	P(-)+Visual(+)
			P(-)+V(+)
Vestibular	Swivelable	Robustness	V(-)+A(+)
	Swingable		V(-)+T(+)
			V(-)+Visual(+)
	Rockable		V(-)+P(+)

Table 4.6 Marked Sensory Design Guidelines 1

The visual system requires a balanced approach to sensory input, so the visual system input will be reduced, and the auditory system input will be increased (Table 4.7). The final design elements have all been highlighted. Next, different sketches will be given for each design element.

Sensory Design Guidelines			
	+	-	=
Auditory	**Use curved shape**	Non-movable parts	A(-)+T(+)
	Low enclosure	Increasing the air gap	
	Use curved Top	Dividing panels	A(-)+Visual(+)
	Lower back	Use reverse curved shapes	
	Moveable parts	High enclosure	A(-)+P(+)
	Screening Panel	Higher back	A(-)+V(+)
	Flat	Fold	
Tactile	Provide pressure and weight	**Alcoves (Hide space)**	T(-)+A(+)
	Raised bumps	**Smooth surface**	T(-)+Visual(+)
	Smaller personal space	**Larger personal space**	T(-)+P(+)
	Multi-sensory experiences	**Single sensory experience**	T(-)+V(+)
Visual	Complex lines	**Clean lines**	Viusal(-)+A(+)
	Open space	**Block visual distractions**	Visual(-)+T(+)
	Warm colors	**Cooler colors**	Visual(-)+P(+)
	Differentiation	**Harmonization of space**	Visual(-)+V(+)
Proprioceptive	**Asymmetrical structure**	Symmetrical structure	P(-)+A(+)
			P(-)+T(+)
	Non-fixed elements	Fixed elements	P(-)+Visual(+)
			P(-)+V(+)
Vestibular	Swivelable	Robustness	V(-)+A(+)
	Swingable		V(-)+T(+)
			V(-)+Visual(+)
	Rockable		V(-)+P(+)

Table 4.7 Marked Sensory Design Guidelines 2

4.5.1 Design Feature 1: Auditory +

Seven sketches were created that added the features from the increase auditory sensory input category, including the use of a curved shape, lower back and enclosure features.

Concept 2 was selected for the next stage of design.

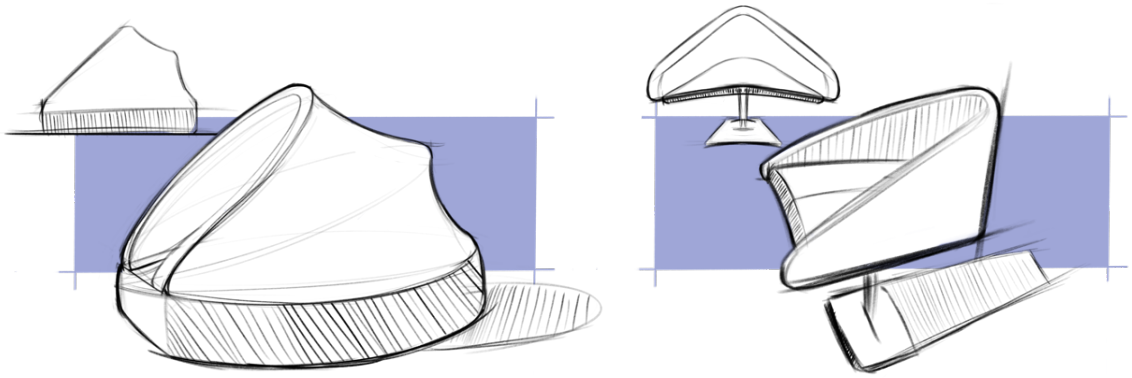

Figure 4.2 Concept 1&2

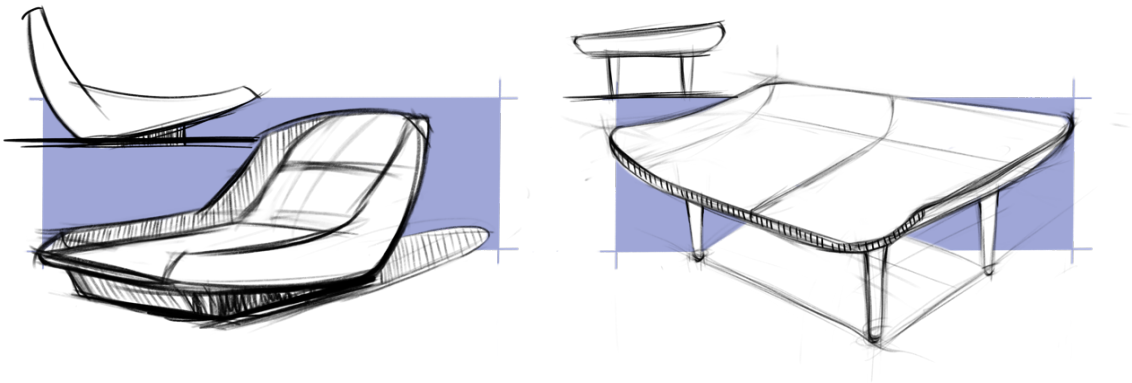

Figure 4.3 Concept 3&4

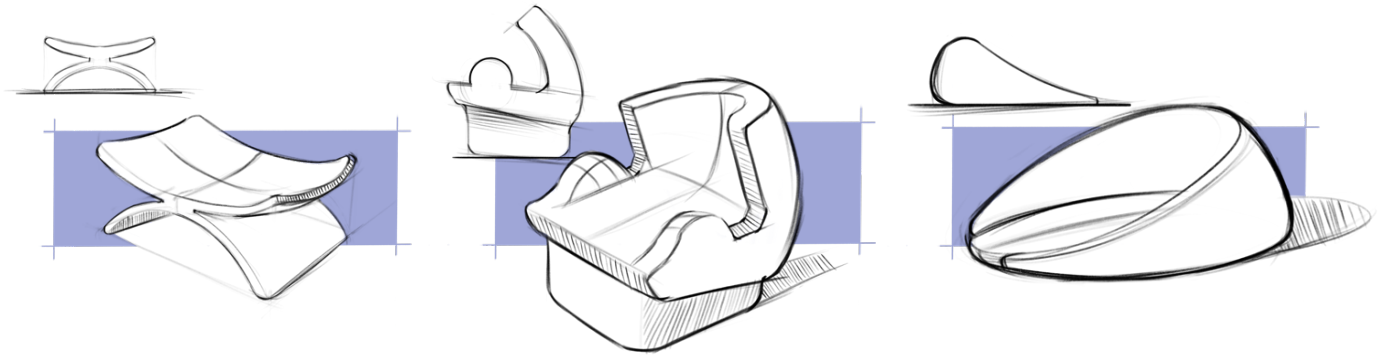

Figure 4.4 Concept 5,6&7

4.5.2 Design Feature 2: Tactile -

The reduced tactile input to concept 2. To six sketches were added the features from the reduced tactile sensory input category, including the use of curved shape, lower back and enclosure features. Concepts 8 and 9 were selected to carry out one phase of the design.

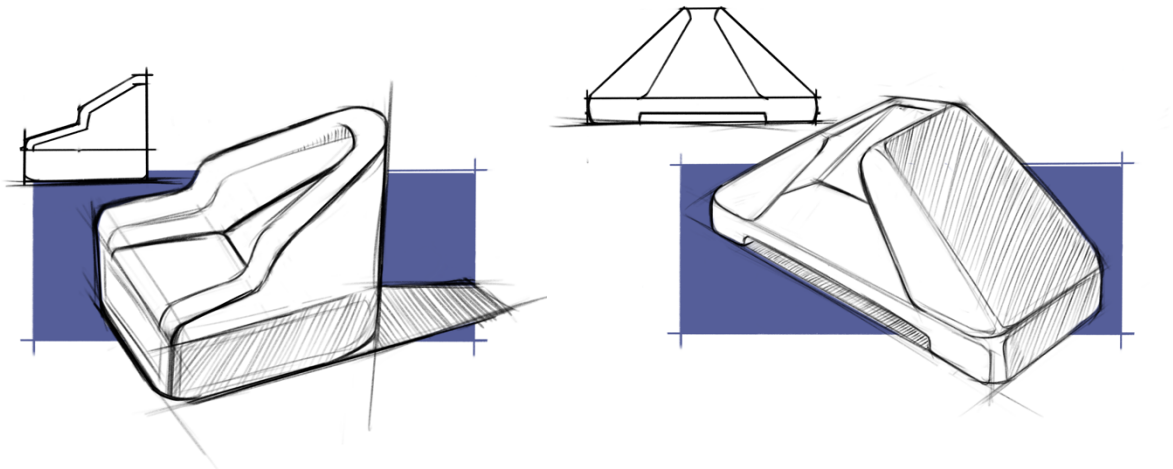

Figure 4.5 Concept 8&9

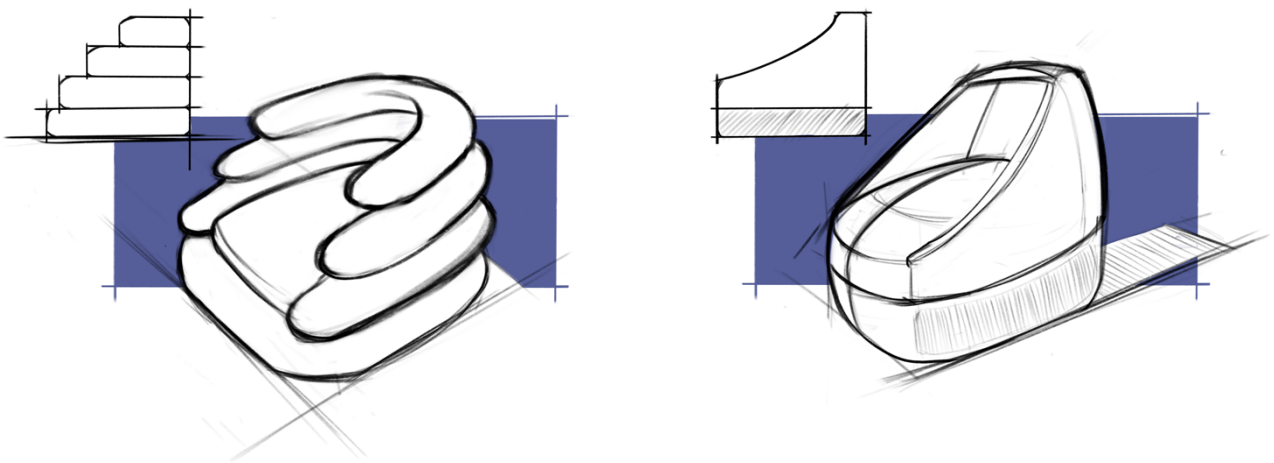

Figure 4.6 Concept 10&11

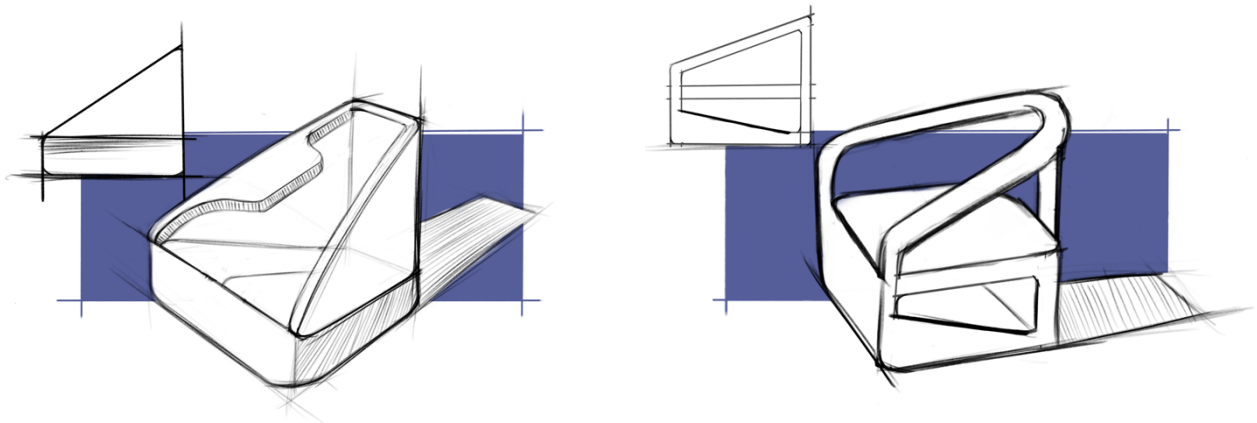

Figure 4.7 Concept 12&13

4.5.3 Design Feature 3: Visual -

In this stage, a cooler color was added to concept 8, and the lines were reduced to make the overall furniture look cleaner and to help Mike reduce visual input. The addition of cooler color and a blocking feature to concept 9 also helped Mike reduce visual input. Concepts 14 and 15 were selected for the next phase of the design.

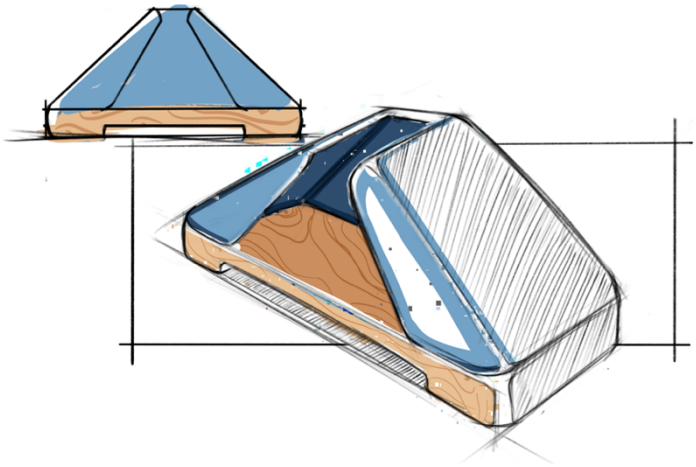

Figure 4.8 Concept 14

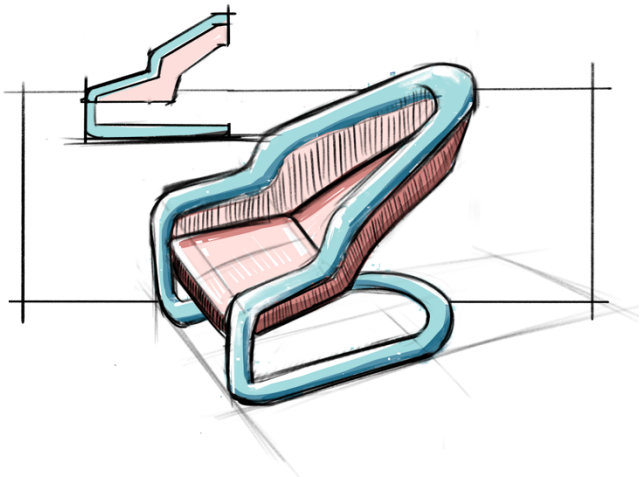

Figure 4.9 Concept 15

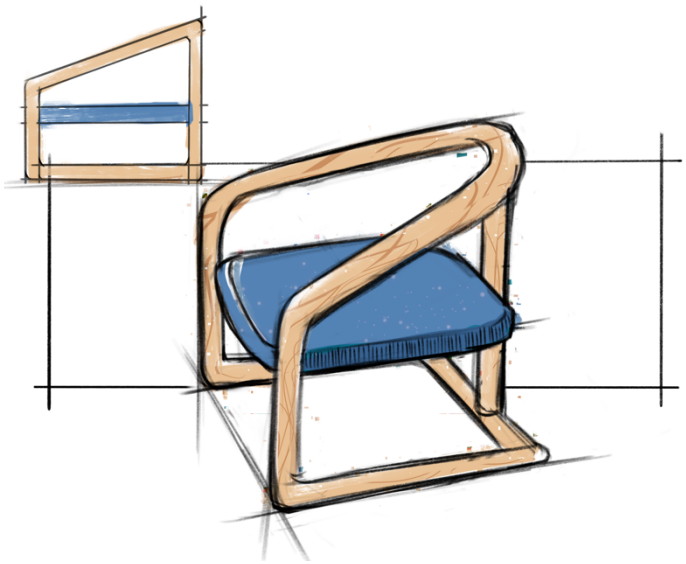

Figure 4.10 Concept 16

4.5.4 Design Feature 4: Proprioceptive +

The purpose of this phase was to help Mike increase proprioceptive input by changing the appearance of concepts 14 and 15 (add asymmetrical structural design features). The final sketch chosen is concept 17, because the asymmetric structure can help Mike increase proprioceptive input, the cooler color and front partition can reduce Mike's visual input, the partition can also create a small space where Mike can hide, and when Mike feels a tactile input overload, he can hide behind the partition and reduce tactile input. The curved shape can create more echoes to help Mike increase auditory input.

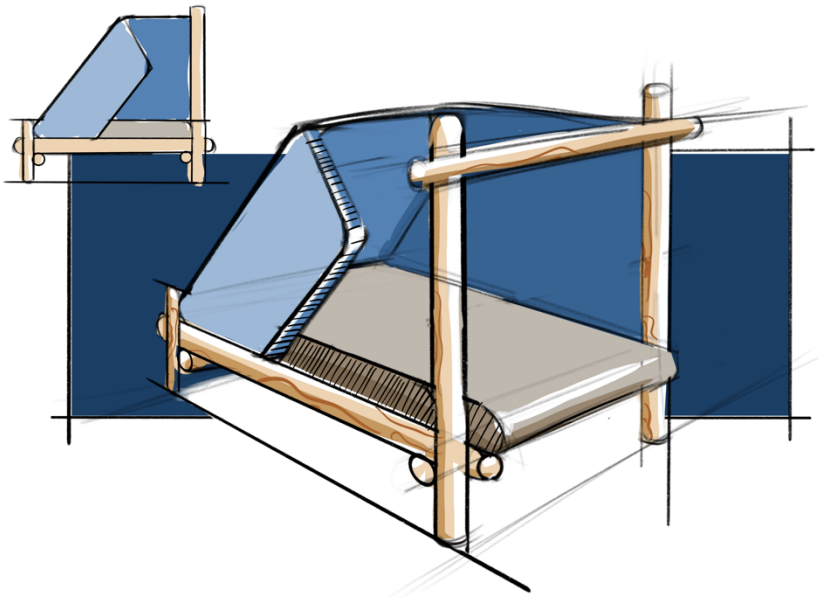

Figure 4.11 Concept 17

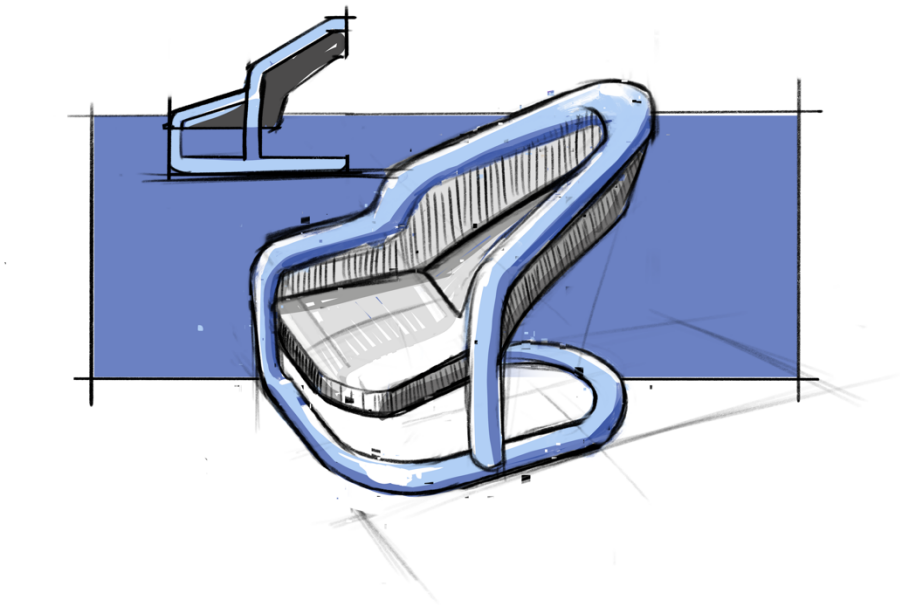

Figure 4.12 Concept 18

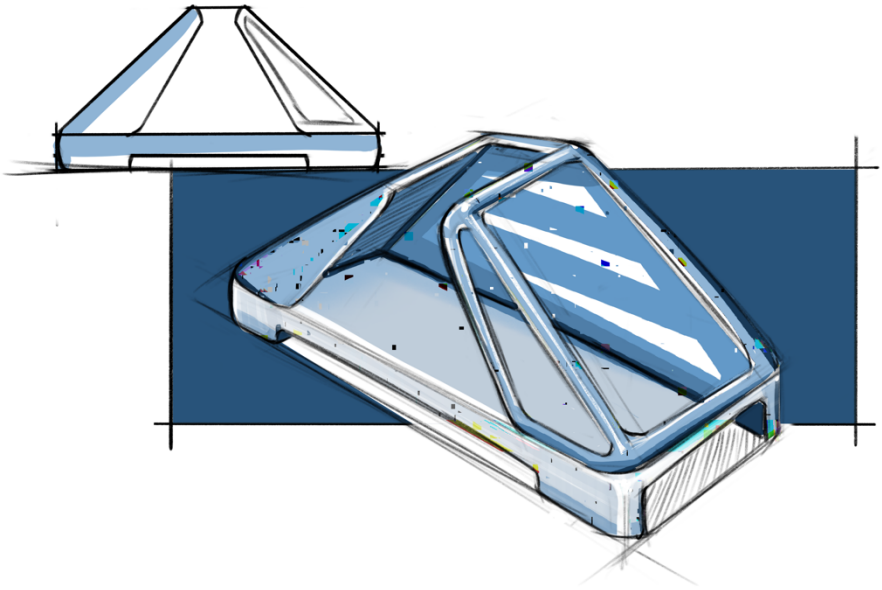

Figure 4.13 Concept 19

4.5.5 CAD Model

Figures 4.14 and 4.15 show the final design according to the design guidelines. A seemingly simple chair can be tailored to Mike's specific needs and meet his requirement of sensory input, the curved shape can help Mike increase auditory input, a semi-shaded design in front can create a safe environment for Mike and effectively reduce tactile input, the cool colors and clean lines can reduce Mike's visual input, and asymmetrical appearance design can increase Mike's proprioceptive input.

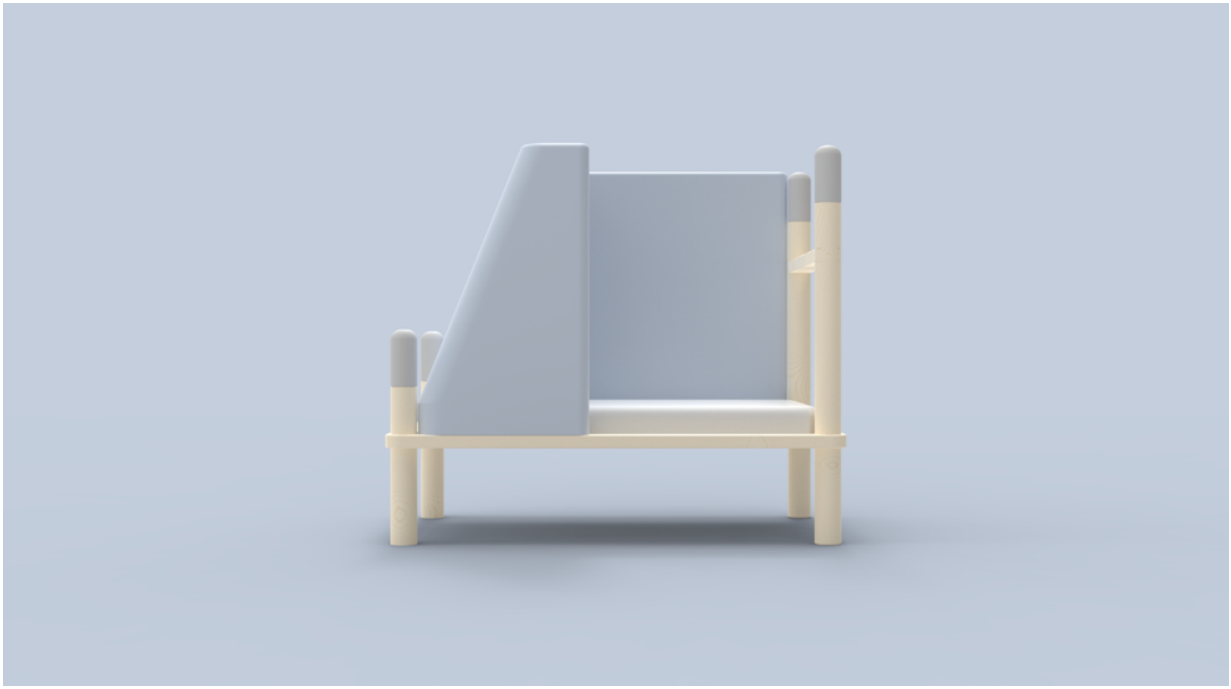

Figure 4.14 Final CAD rendering

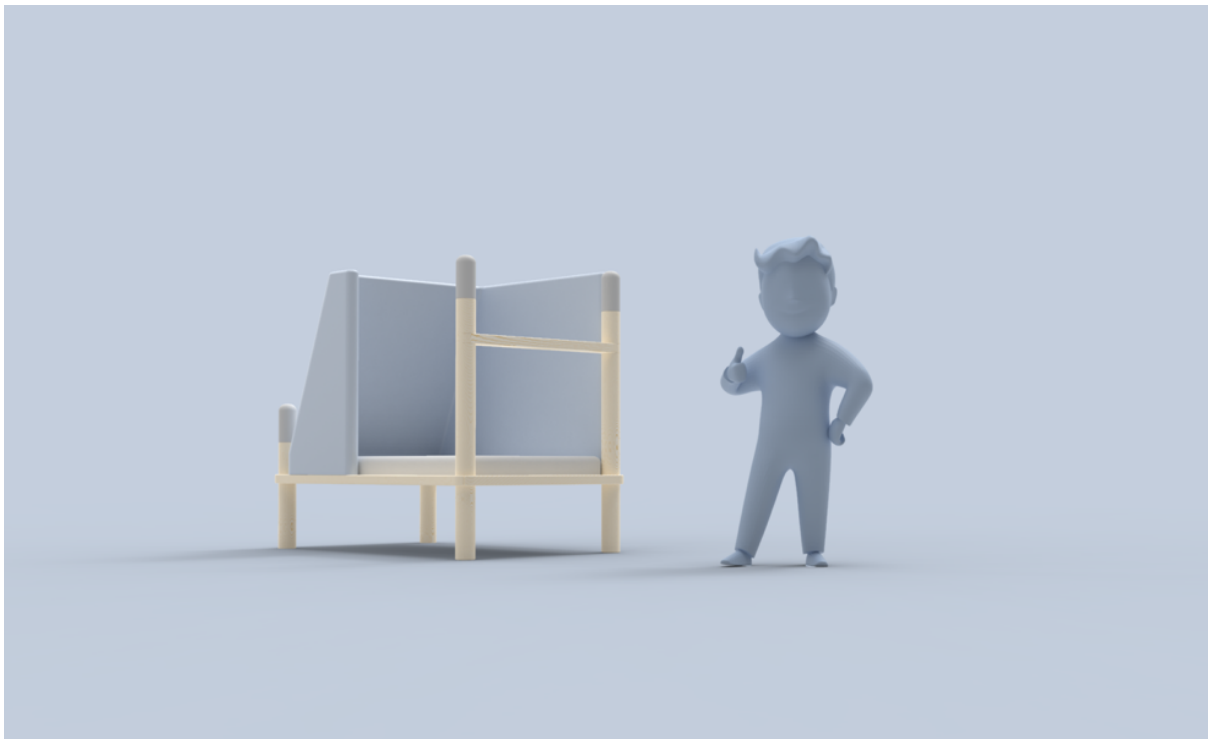

Figure 4.15 Final Rendering

4.5.6 Color Option

Because Mike needs less visual input, the choice of colors for the furniture should lean toward cooler tones, and Figure 4.16 shows some possible color choices.

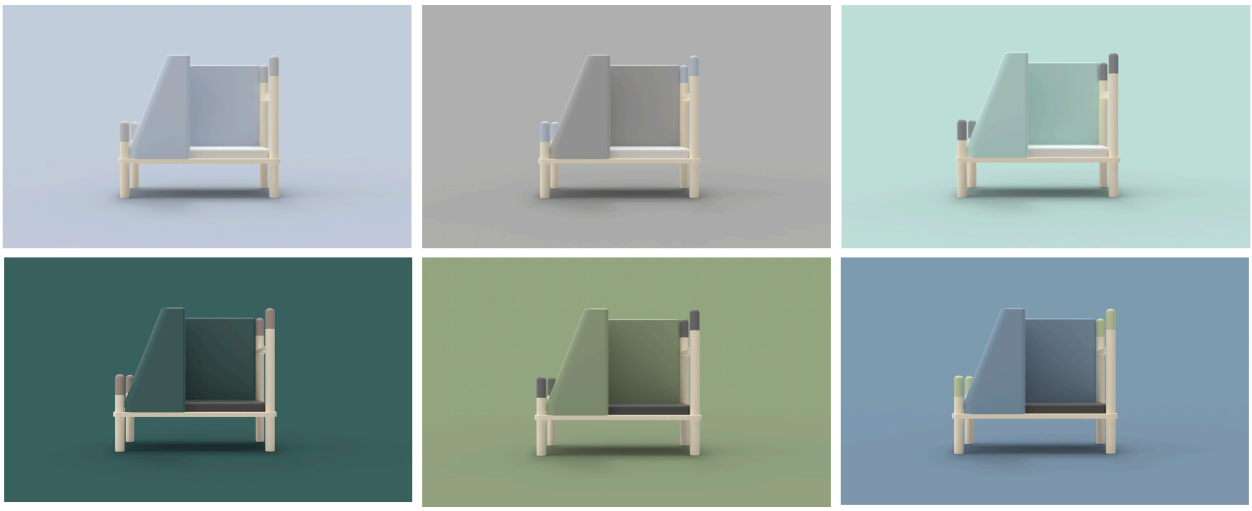

Figure 4.16 Color Options

4.5.7 Chair's Features

This chair uses an enclosure with curved corner to help Mike increase the input of the auditory system. The enclosure can create a lot of echo reflection (Figure 4.17).

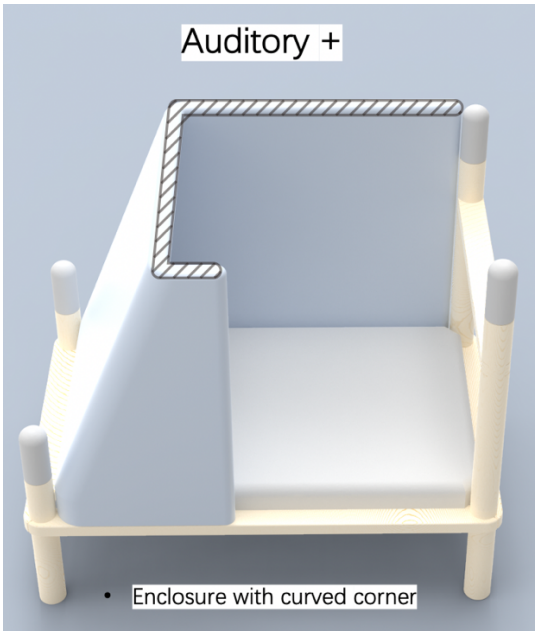

Figure 4.17 Enclosure with curved corner

As in Figure 4.18, the shaded part is a hiding area designed for Mike to help Mike reduce tactile input. It also increases the size of the personal area, which can also help Mike reduce tactile input (Figure 4.19).

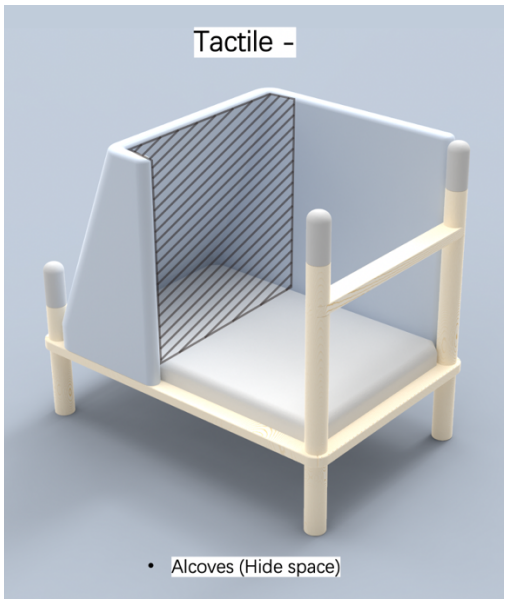

Figure 4.18 Alcove for Mike

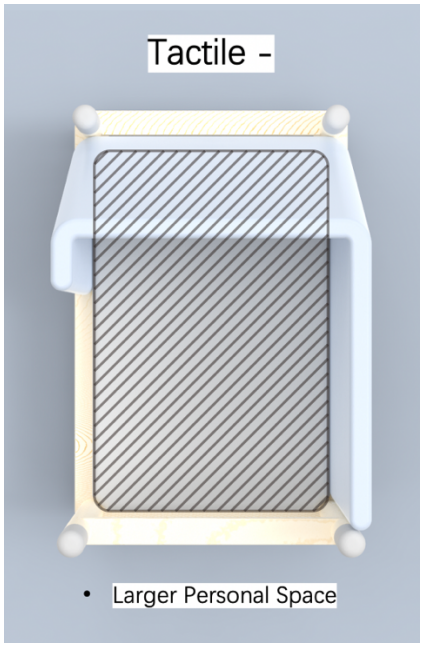

Figure 4.19 Large Personal Space

The overall appearance of the chair is made up of clean lines that help Mike reduce visual input (Figure 4.20) and also uses cool colors that can better reduce visual input (Figure 4.21).

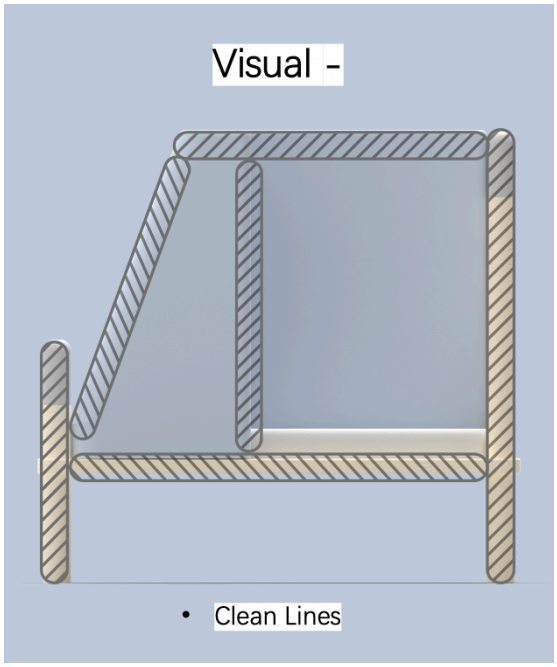

Figure 4.20 Clean Lines

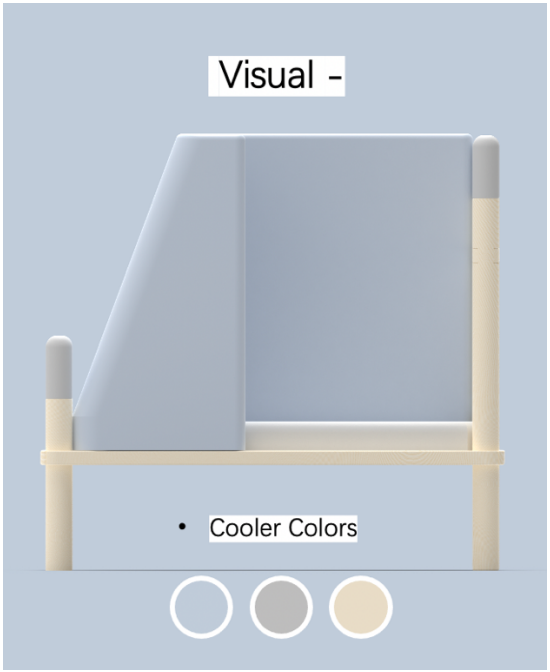

Figure 4.21 Cooler Colors

The overall appearance of the chair uses an asymmetrical structure to help Mike increase proprioceptive input (Figure 4.22).

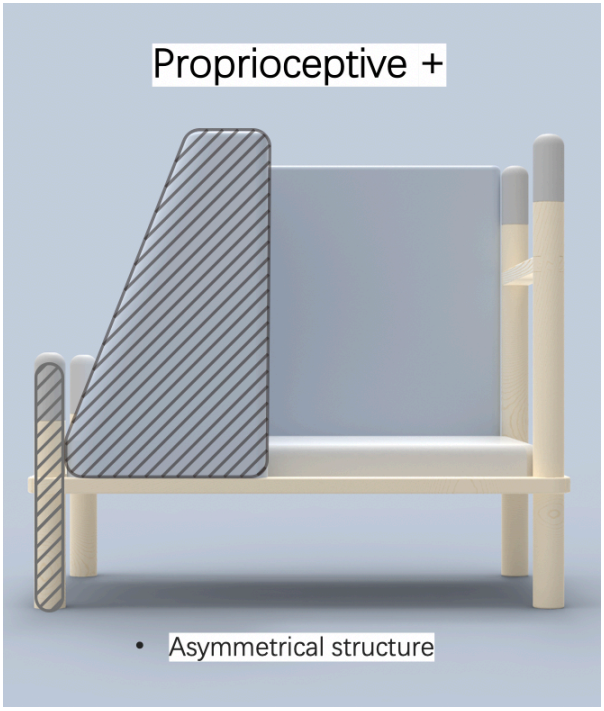

Figure 4.22 Asymmetrical Structure

This chair also uses a chinese joint called a combination of square and round to create another sense of asymmetrical structure. The top of each pole uses a removable rubber cover, which can protect Mike from sharp edges. On another hand, it also can be replaced with different colors to add more fun on this chair (Figure 4.23).

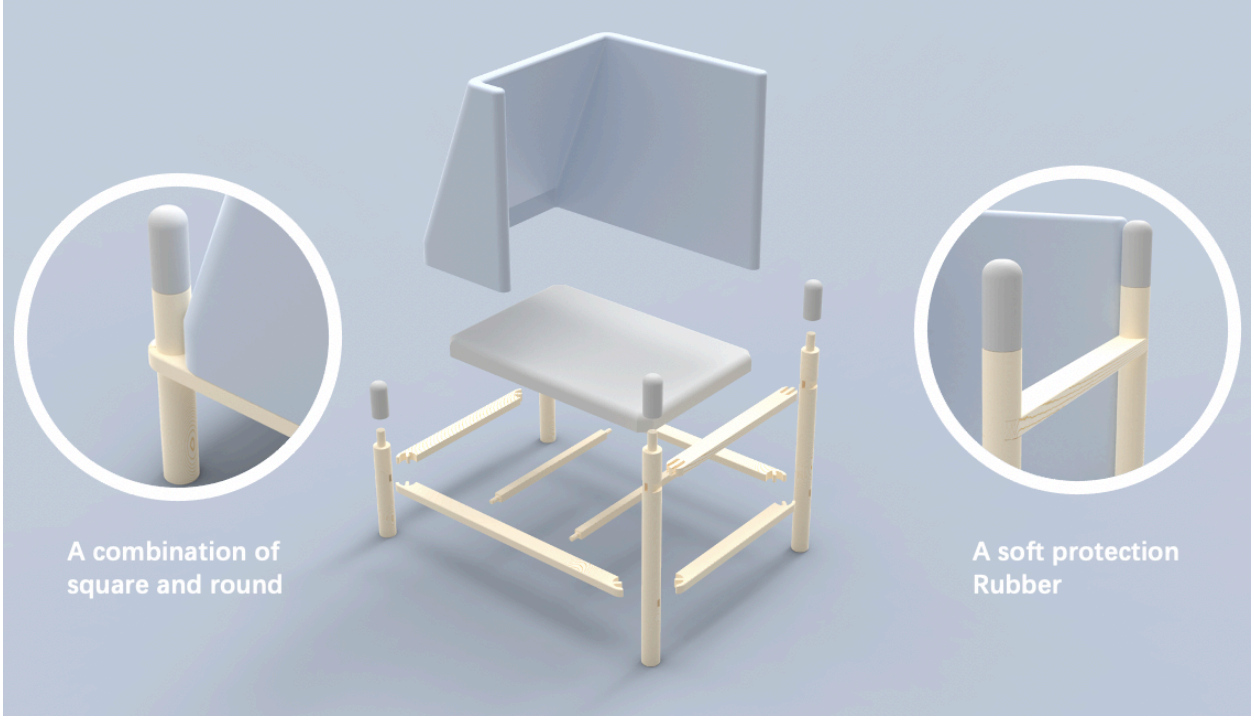

Figure 4.23 Exploded View

This chair only has three different parts. First part is the wood shelf. The second part is a cushion. Last part is the shell, which can create an asymmetrical structure and a place for mike to hide (Figure 4.24).

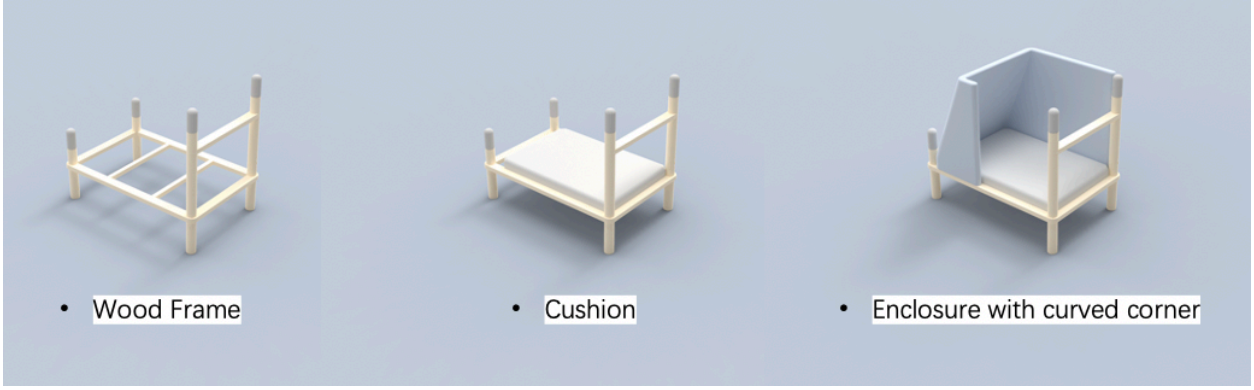

Figure 4.24 Assembly Process

Mike is a five-year-old boy who is 43 inches tall. The height of this chair is 45 inches, the width is 24 inches, and the length is 42 inches. It will give Mike a large personal space and allow him to reduce tactile input (Figure 4.25).

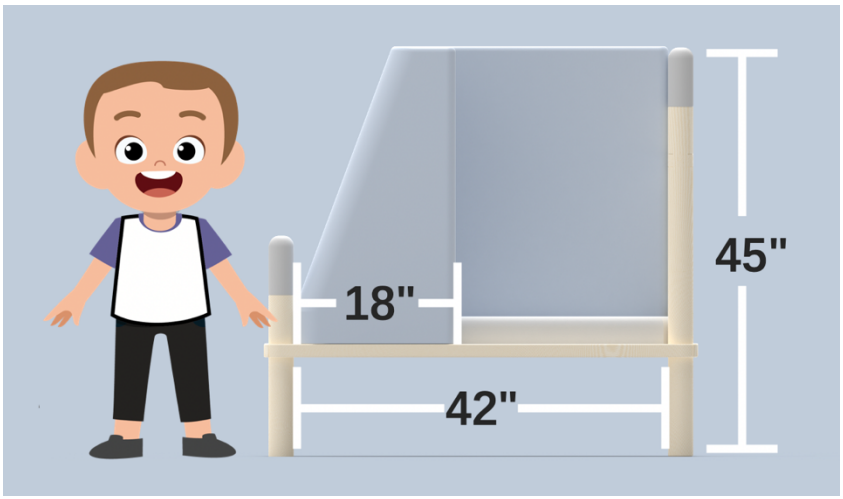

Figure 4.25 Measures

4.5.8 Situational Rendering

Next, some rendering will be used to show Mike's reaction when he first saw the furniture of the application design guide, welcome to Mike's world (Figure 4.26).

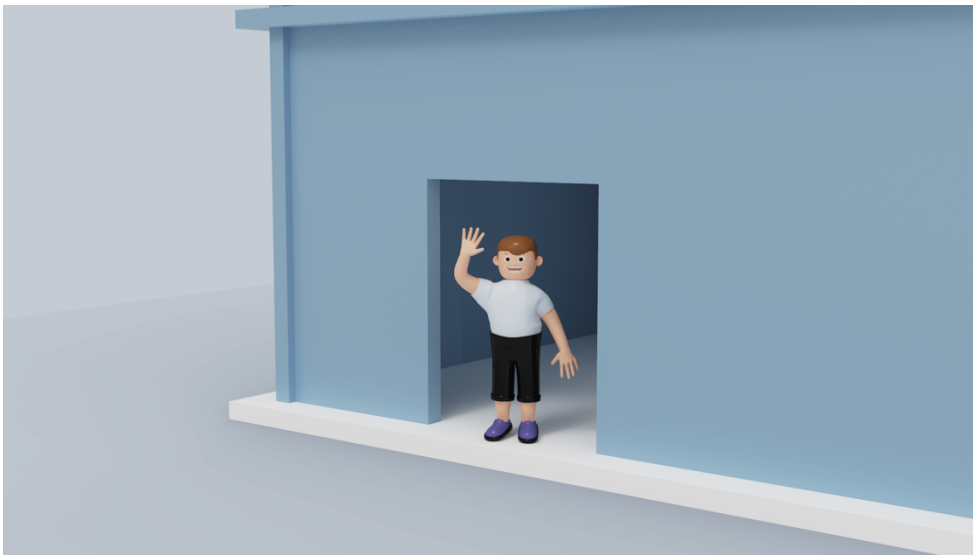

Figure 4.26 Welcome to Mike's World

Mike walked into the room; the furniture looked very ordinary. Mike saw the bright colors of the furniture and felt visual input overload, and he felt less comfortable.

Figure 4.27 Walk into the Room

He turned around and saw a chair designed especially for him. The color of the chair and the simple lines helped him reduce the visual input. He was surprised by the sense of calm the chair gave him.

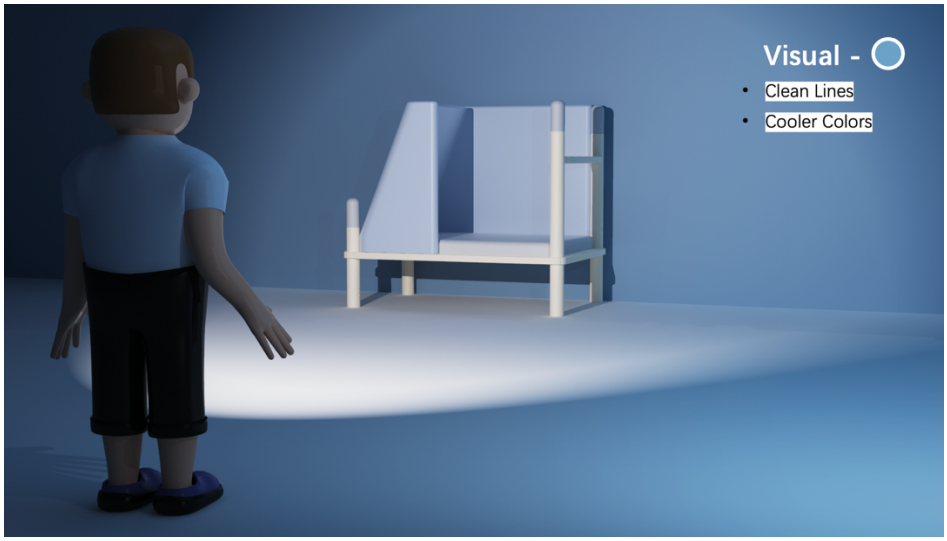

Figure 4.28 Reduced Visual Input

He stood in front of the chair and looked at it carefully. Because of the asymmetrical appearance of the chair, he felt an increased input in proprioception.

Figure 4.29 Increased Proprioception Input

He sat on the chair because the enclosure with curved corner appearance design can help increase the sound reflection and increase the auditory input. Mike felt that he could noticed more tiny sounds.

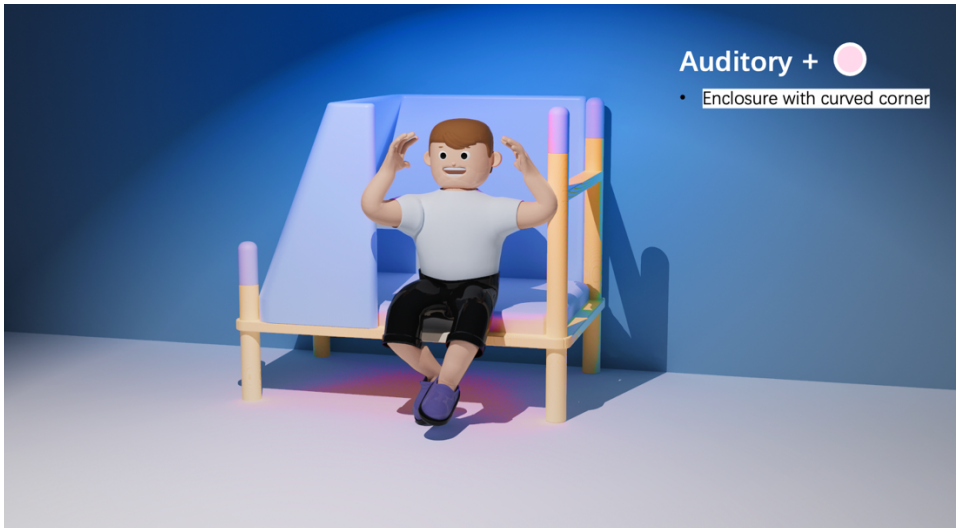

Figure 4.30 Increased Auditory Input

He found that the chair could hide himself inside and he ducked in, where he felt very safe, because the smooth material and the place where he could hide made him feel the reduction of tactile input.

Figure 4.31 Reduced Tactile Input

He was very pleased with the chair, which applied design guidelines to create a chair just for Mike, helping him to reduce the sensory input he hated and increase the sensory input he wanted. It creates a sensory-friendly environment for Mike.

Figure 4.32 Happy Mike

Chapter 5 Conclusion

The purpose of this thesis is to develop a design guideline for autistic children with sensory impairments. Due to the special characteristics of autistic children, it is difficult for designers to get useful information in the process of communicating with the children. This design guideline can help designers to find design directions using observation. Through the research, the relationship between different sensory processing modes and challenging behaviors is found, and the designers are provided with sensory input modes for different challenging behaviors, and three input modes are given: increase, reduce, and balance, which can be applied to children with autism's auditory, visual, tactile, proprioceptive, and vestibular senses respectively. Design elements are provided for the input of different sensory systems. Through this design guideline, designers can create sensory-friendly environments for children with autism by providing them with physical forms of assistance that meet the sensory needs of children with autism in a more rational way.

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