

Design interventions for Sensory comfort of Autistic children

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Abstract

The aim of the study was to arrive at design interventions for sensory comfort of Autistic children. The scope of study included vast and systematic review of literature and few observation studies supplemented with survey of caregivers. A matrix with detailed design guidelines was the study outcome. It was concluded that designing for sensorily comfortable spaces could make the child more manageable and formulated guidelines could aid the design process. But the risk of child insisting on the same setting with prolonged exposure cannot be neglected. Future potential research areas involving design interventions for possibly enhancing neural connectivity in brain regions involved in sensory perception and integration, is also discussed.

Keywords: Architectural design; Autistic children; Interdisciplinarity; User centered design; Design behaviour

Introduction

An exquisite piece of architecture invites and guides us to be more sensitive to the environment [1]. Changes in the environment change the brain, and therefore our behaviour [2]. According to Dzebic, Perdue, & Ellard [3], the physical properties of built environments influence mental health [4] and the pleasantness of our experiences [5]. According to Simon Unwin [6], in the physical realization and actual experience of architectural design, the spaces created are modified by the following elements-light, colour, sound, temperature, air movement/ventilation, smell, texture, scale and time. Altering these design elements could impact the sensory experience of space and could possibly change the user response and behavior. In the design of spaces for behavioral impact in children, a number of technical design features are found to be related to positive behavioral outcomes in children-good acoustics, lighting and indoor climate control, non-slippery floor surfaces and warm colours [7]. In the specific case of Autistic children, the architectural design interventions used so far can be broadly classified into sensory design and neurotypical design approaches [8]. The former involves designing environments that make autistic children sensorily comfortable while the latter involves exposure to as typical a real world environment as possible. The sensory design approach is based on the concept of the sensory environment being a major role player in the process of perception and behavior [9] and the aim of the study was to arrive at design interventions for sensory comfort of Autistic children. The scope of the study included vast and systematic review of literature and few observation studies supplemented with survey of caregivers. The review involved literature on design interventions for sensory comfort as well as understanding Autistic children for user-centered design guidelines. The findings were augmented by the inferences from observation studies of Autistic children at their homes and questionnaire survey of caregivers. A matrix with detailed design guidelines was the study outcome. It was concluded that designing for sensorily comfortable spaces could make the child more manageable and formulated guidelines could aid the design process. But the risk of child insisting on the same setting with prolonged exposure cannot be neglected. Future potential research areas involving design interventions for possibly enhancing neural connectivity in brain regions involved in sensory perception and integration, is also discussed.

Design interventions for sensory comfort

Visual properties of designed environments and user experience

The existing theories and studies on the visual properties of built environments and how they shape experience are reviewed and summarized.

Visual complexity for arousal

Berylene (1970) [10] argues that much of the human exploratory behaviour and preferences for certain objects and scenes is dependent on maintain appropriate levels of arousal, which in turn is influenced by stimulus complexity and that visual complexity not only influences preference but also promotes exploratory behaviour and leads to greater information acquisition [3].

Prospect - refuge for security

In 1975, Appleton published the book, 'The experience of landscape', in which he proposed the prospect-refuge theory. As Dosen and Ostwald, 2012 describes it, the theory seeks to describe why certain environments feel secure and thereby meet basic human psychological needs, by providing people with the capacity to observe (prospect) without being seen (refuge). Prospect is a function of many built environmental properties including wide views (panoramas) or vistas (peep holes) visible from one's location. One of the main concepts posited by the prospect-refuge theory is the notion that environments which provide a person with visual information about their surroundings will lead to preference [3].

Visual properties for attention restoration

The attention restoration theory was postulated by Kaplan and Kaplan in 1989 [11]. Directed attention plays an important role in human information processing system and its fatigue, and the theory

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provides an analysis of the kind of experiences that leads to recovery from such fatigue [12]. The four components of such a restorative experience are-fascination (offering processes that people find engrossing and attention is effortless leaving ample time for thinking about other things), being away (a conceptual transformation - a change in direction of one's gaze or the same environment viewed in a different way), extent (be rich enough with sensory stimuli to engage the mind but not lacking extent) and compatibility (between the demands of the environment and one's purposes and inclinations).

Visual properties for negative emotional states

According to a study, the following visual properties were identified [13], which directly affect brain behaviour linked to the negative emotional states of anxiety, fear or pain and which have a broader applicability for the design field:

a. Valence and arousal

The pleasantness-unpleasantness of visual stimuli (valence) and soothing or agitating visual stimuli (arousal) could act as an emotional probe. In the studies conducted by Anders it was found that amygdala activity was involved in the response to valence in visual stimuli and that thalamic and cortical activity increased with arousal. Unpleasant compared with neutral and pleasant visual stimuli can activate the amygdala and arousal can activate the higher level cortical activity, both inducing stress.

b. Ambiguity

Ambiguous content in visual stimuli can cause stress, for example, use of abstract art with ambiguity could have a negative effect on restoration by inducing stress.

c. Familiarity and novelty

There is a visual preference for familiar real objects from nature over novel patterns. Novelty is associated with a sense of potential threat according to Upali Nanda et.al [13].

d. Spatial frequency

Spatial frequency is defined as the frequency of change in pixel values across an image as a function of distance. High spatial frequencies represent abrupt changes in the image such as edges and fine details. Amygdala responses resulting in fear was greater for low spatial frequencies of visual stimuli [14].

e. Contour

Bar and Neta [15] found that amygdala was significantly more active for everyday sharp objects compared with their curved counterparts stressing the human preference for curved contours.

Visual properties for positive emotional states

According to Kaplan and Kaplan, environments that allow a shift towards more positive emotional states are called restorative environments [16]. According to Upali Nanda [13] in psycho physiological studies, a decrease in stress is always linked to restoration or healing. As Esther Sternberg suggest in her book 'Healing Spaces', the calming influence of nature views could be because repeating patterns are pleasing to the eye and the existence of such a self-similar symmetry called fractal geometry could account for the stress reduction on exposure to nature views. Ary Goldberger, a Professor of Cardiology and researcher into heart rate variability, in his paper in 1996, has also proposed that fractals are satisfying to the human mind [17].

In this context, it is worthwhile to look at the concept of fractal geometry, a geometry underlying nature and natural elements. A fractal is a mathematical set that exhibits a repeating pattern that displays at every scale. According to B.B.Mandelbrot a vast range of natural objects are fractals, including mountains, clouds, rivers and trees [18]. Ranging from snowflakes to flowing water, fractals are the underlying geometry of nature. There are supporting research findings that prove that exposure to fractal art could bring about physiological stress relief [18]. Fractal geometry has been applied in architecture design successfully in building geometry [19]. The prevalence of artificial fractals suggests the possibility that we have been making use of fractal stress reduction throughout history.

Summary of findings and inferences

The summary of the literature review of the visual properties of built environment that influence our mental health and pleasantness and aid design of sensorily comfortable spaces is as follows (Table 1).

Effect of other sensory properties of designed environments

The properties perceived through sensations of smell and taste, were exempted from the scope of the study due to limited application of findings in the design process (Table 2).

Understanding Autistic children

Autism and its symptoms

Autism is a developmental disorder characterized by difficulties with social interaction, social communication and an unusually restricted range of behaviour and interests [23], the signs and symptoms of which can change dramatically over time in a given individual [24]. Referred to as the triad of impairments (Wing & Gould, 1979), the criteria for the identification of autism include impairment of social interaction; impairment of social communication and impairment of social imagination which can be explained as follows [25].

- Impairment of social interaction refers to a reduction of non-verbal signs of interest in being with another person; making eye contact and social smile, responding to affectionate physical contact and waving goodbye.
- Impairment of social communication refers to a decreased ability to converse non verbally and verbally with another person and also often have problems understanding what is said to them.
- Impairment of social imagination refers to a decreased capacity to think about and predict the consequences of one's own actions for oneself and for others.

The non triad features or clinical impressions of Autism as listed by Frith and Happe in 1994 include the following -obsessive desire for sameness (insistence on sameness), restricted range of interests, islets of ability, idiot savant abilities (striking in 1 in 10 Autistic children), excellent rote memory and preoccupation with parts of objects.

Cognitive and neural theories explaining Autism

A detailed study of the theories explaining autism and associated sensory symptoms - cognitive (based on cognitive differences) and neural (based on neuroanatomical differences) theories; was done. The cognitive theories reviewed included the Theory of Mind [26], Theory of weak central coherence [27]. Theory of executive dysfunctions [13] and Empathizing - Systemizing theory [1]. Though

Literature finding	Inferences		Inferences
Literature source	Visual properties of built environment	Positive change induced	Possible design guideline
Berlyne [10]	adequate visual complexity for inducing a level of arousal.	Adequate arousal	Provide contrasting colours/textures for surfaces, include reflective surfaces/ mirrors, provide lighting for contrast and lighting for contrast and shadows
Prospect - refuge theory by Appleton [20]	capacity to observe without being seen; environments with visual information about their surroundings.	Security	Ensure means of unobstructed outside view
Attention restoration theory by Kaplan and Kaplan [11]	4 aspects - fascination (offering processes that people find engrossing and attention is effortless leaving ample time for thinking about other things); being away (a conceptual transformation - a change in direction of one's gaze or the same environment viewed in a different way); extent (be rich enough with sensory stimuli to engage the mind but not lacking extent); compatibility (between the demands of the environment and one's purposes).	Attention Restoration	Incorporate more natural elements in design like pebbles/ indoor plants and include natural looking surface finishes like wood/stone finish.
Nanda, Zhu and Jhansen [13]	pleasant (valence) and less arousing visual stimuli; non ambiguous content in visual	Anxiety reduction	Curve the edges of walls and surfaces, include a variety of curved design
	Stimuli; familiar real objects from nature; high spatial frequencies and curved contours		Elements incorporate contrasts in edges and use design elements from nature
R.P.Taylor [18]	nature views and application of fractal patterns in design of spaces.	Restoration or healing	Provide nature views ad design fractal patterns where nature views are not possible (absence of fenestration).

Table 1: Visual properties of built environment.

Literature Source	Properties of the designed environment	Effect on user
	perceived through sensations	
	Auditory (hear)	
Epstein [21]	Noise	Induce stress
	Tactile (touch)	
Berlyne [10], Naghizade, Mohammad and Ostadi, Maryam [22]	Though depth perception aided by tactile sensation, very high visual complexity due to multiple textures may cause stress	Induce stress

Table 2: The auditory and tactile properties of designed environments and their effect on user.

most of the cognitive theories could explain the social interaction and communication difficulties, they did not provide an explanation for the sensory symptoms. The neural theories reviewed the theories of neural connectivity abnormalities [28], malfunctioning based around the amygdala (Schultz, 2005) and mirror neuron dysfunction (Ramachandran & Oberman, 2006).

Cognitive theories

Although autism was first explained by Kanner in as early as 1943, the nature of the core deficits underlying this disorder is still vague. There are several theories and hypotheses explaining the persistent deficits in Autistic children. The theories explaining Autism and associated symptoms can be broadly classified into cognitive theories and neural theories - the former on the basis of cognitive differences and the latter based on neuroanatomical differences.

a. Theory of mind (Baron Cohen, Alan.M.Leslie and Uta Frith 1985)[26]

In 1985 'Cognition' published an article by Baron Cohen, Alan.M.Leslie and Uta Frith entitled "does the Autistic child have a theory of mind?" [28]. The theory of mind (ToM) hypothesis focussed on explaining the poor performance of Autistic children on false belief tasks, where the participants were required to interpret a situation from the viewpoint of another, and suggested that the central deficit in Autism was the ability to 'read' others' minds in social situations [14] called this ability 'mentalizing'. The theory of mind account has been remarkably successful in making specific predictions about the triad of impairments shown by people with Autism. However, it cannot explain the non-triad features of Autism or earlier experimental evidence of abnormal assets and deficits on non-social tasks [28].

b. Theory of weak central coherence (UtaFrith, 1989)[27]

Frith's formulation of weak coherence (originally called 'weak central coherence') in 1989 was built on the observations of local processing biases in Autism, combined with the relative failure to extract the gist or meanings of events in everyday life. However in 2006, Happe and Frith reformulated the theory in 3 important ways in response to other empirical findings:

- (1) It is no longer regarded as a core deficit in central processing but a more secondary outcome characterized by a 'detail - focussing' processing style,
- (2) This processing style can be overcome in certain situations,
- (3) It is one aspect of a more detailed cognitive profile which includes problems with Theory of Mind [1].

c. Theory of executive dysfunctions

The dominant cognitive theory of Autism is the theory of executive dysfunctions, executive functions being defined as the ability to maintain an appropriate problem-solving set for attainment of a future goal which includes behaviours such as planning, impulse control, inhibition of irrelevant responses, set maintenance, organized search and flexibility of thought and action [29]. This theory accounted for many of the non-social symptoms in Autism, such as repetitive and obsessional behaviours.

d. Empathizing - Systemizing theory [1]

According to Baron-Cohen, 2009, the Empathizing - Systemizing theory of Autism explains the social and communication difficulties in Autism by reference to delays and difficulties in empathy, while

explaining the area of strength by reference to intact or even superior skill in systemizing. Empathy involves identifying someone else’s mental state and having an appropriate emotional reaction to another person’s thoughts and feelings. Systemizing is the drive to analyse or construct systems, such that when we systemize we are trying to identify the rules that govern the system in order to predict how that system will behave.

Neural theories

a. Neural connectivity abnormalities [28]

According to Belmonte et.al. 2004, abnormal neural connectivity could be the reason for certain motor, cognitive and social difficulties in Autism. Accordingly, in Autism, cerebellar activation is abnormally low during a task of selective attention and abnormally high during a simple motor task which correlates significantly with reduced size of cerebellar sub regions and resultant connectivity abnormalities.

b. Malfunctioning based around the amygdala [30]

Schultz, 2005 in his paper on face perception abnormalities in Autism integrated with fMRI literature presents a model of Autism. This model argues that there is an early developmental failure in Autism involving the amygdala and development of certain cortical areas, specifically the fusiform ‘face area’ of the ventral temporal lobe. The amygdala – fusiform system supports the face recognition and social cognitive skills and hence deficits in this network is the cause for Autism.

c. Mirror neuron dysfunction and salience landscape theory

There are certain neurons that are part of determining the intentions of other individuals by mentally stimulating their actions. These neurons called the mirror neurons, typically firing in response to seeing someone perform an action, are involved in language development and empathy. According to V.S.Ramachandran and L.M.Oberman, 2006 dysfunctional mirror neuron system could explain some of the primary symptoms of Autism, including isolation and absence of empathy. A complimentary hypothesis, the salience landscape theory, could account for secondary symptoms of Autism such as hypersensitivity, avoidance of eye contact, etc. According to this theory, in children with Autism, the connections between the sensory areas and the amygdala may be altered, resulting in extreme emotional responses to trivial sensory stimuli.

Atypical sensory behaviors

Deficits in the development of sensory abilities might be the original problem underlying social cognition impairments in autism [15] with over 90% of Autistic children showing atypical sensory behaviours [31]. The sensory processing pattern in any child is dependent on the neurological threshold and behavioral response (passive/ active strategy for responding). According to Frith [32], autistic children have more intense responses in sensory processing patterns and exhibit sensory symptoms.

Designing for Sensory comfort of Autistic children

Sensory subtypes and possible design interventions

Sensory subtypes of Autistic children

According to Frith [32] there is a relationship between a person’s neurological thresholds and self-regulation strategies and that the interaction of these functions creates four basic patterns of sensory

processing. Neurological threshold is the point at which there is enough input to cause a nerve cell or a system to activate. When a stimulus is strong enough to trigger the threshold, it causes activation and we notice it [33]. Each person has a personal range of thresholds for responding to sensory inputs and thresholds might be different for each type of sensory input. Self-regulation corresponds to the behavioural part, whether the person has a passive or active strategy for responding. Passive means they let things happen around them and then react and active means they tend to control the amount and type of input that is available to them. When these two continuously intersect, 4 basic patterns emerge - low registration, sensation seeking, sensory sensitivity and sensation avoiding (**Figure 1**).

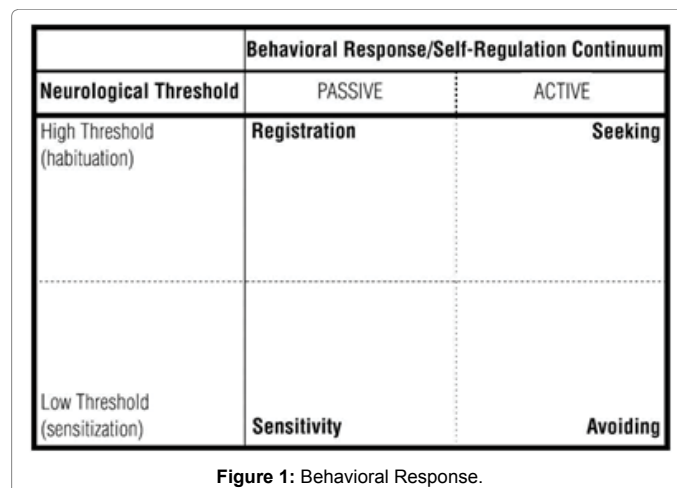
Children with Autism have more intense sensory response patterns. When children have more intense response in low registration, this means that they miss more cues than others that is they fail to notice things. Because these children notice less, one might observe that they are more easy going than other children, and are undisturbed by things that others in the family or classroom notice. When children have a more intense response in sensation seeking, this means that they enjoy sensory experiences and need more sensory input. Because these children enjoy sensory input, one might notice that they move more, hum, or rub their hands on things throughout the day. The children’s interest and pleasure with sensory events might also lead to difficulties with task completion because they may get distracted with new sensory experiences and loss track of daily life tasks. When children have a more intense response in sensation avoiding, this means that they notice things much more than others do. Because these children notice more, one might observe that they are more isolated than other children and are anxious more quickly than others. When children have a more intense response in sensitivity, this means that they detect sensory events more than others. Because these children detect more, one might observe that they are more easily distracted than other children and are easily upset and distractible.

Possible design interventions

The sensory subtypes in autistic children and the management techniques were reviewed and possible design interventions for sensorily comfortable spaces were elicited as given in the (**Table 3**).

Visual perceptual differences and design solutions

One of the many intriguing aspects of autism is that, alongside the defining impairments in social interaction, communication,



and behavioural flexibility, autistic individuals often demonstrate atypical visual perception [34]. For understanding the difference in Autistic children, the normal process of visual perception needs to be understood.

Visual perception

Visual perception begins with various analyses of the initial sensation which becomes progressively more complex until a percept is formed. A percept is the internal representation derived from the initial pattern of stimulation [35]. Visual perception can be well explained by the constructivist approach, which suggests involvement of computations defined over internal representations. Though there is an alternative view that visual perception can be explained without any computations-the non-constructivist approach, it is not detailed because of the inability to provide a precise account of how a percept is established [36]. The constructivist approaches to explaining visual perception includes the Marr’s theory and Biedermann’s Recognition by Components. Marr’s theory being the most influential theory of visual perception [35] is dealt with in detail to get a better understanding of visual perception. According to David Marr, there are three stages in visual perception [21].

a. *First stage - Primal sketch*

This is the first stage in visual perception in which a scene is represented in terms of its fundamental perceptual elements or edges, whose attributes such as length, contrast and orientation are also represented. The basis of primal sketch is to use the variation in light and dark (intensity map) to construct the position of edges. Within the theory of Marr and Hildreth (1980) [37] two filters are used for edge detection in primal sketch- first filter which highlights areas of intensity change likely to be edges and second filter which computes zero crossings or areas where intensity transitions are most marked [35].

b. *Second stage - 2½ D sketch*

In this second stage of visual perception, figure - ground discrimination, depth perception and pattern recognition are added, but the representation will still be viewer centered and not object centered. Figure ground discrimination involves deciding which all objects are in the foreground and what constitutes the background. Depth perception is the combined product of a number of different cues - monocular and binocular. Monocular cues include linear perspective, texture gradients, contrast and motion parallax. Binocular cues include

convergence and stereopsis. Pattern recognition, explained by feature comparison models, assumes that recognition of patterns occurs through the identification of the individual features that comprise that pattern.

c. *Third stage- 3D sketch*

In this stage, an object-centered representation is established which is independent of the specific viewpoint. This allows the object’s features to remain constant irrespective of how one looks at it, known as object constancy.

Visual perceptual differences in Autistic children

In the specific case of Autistic children, many exhibit deviations in this normal process of visual perception and present symptoms indicating a visual sensory difference. The visual sensory difference in Autistic children are classified as hypovisual and hypervisual with the following symptoms [38,39] (Table 4).

Visual processing differences in Autistic children

While designing for sensorily comfortable spaces for Autistic children, the visual processing differences could not be ignored. The visual processing differences in Autistic children are listed as follows-

a. *Lesser susceptibility to visual illusions [40]*

Happe, in 1996 suggested that Autistic individuals were less susceptible to visual illusions (like the Ponzo triangle). However, this finding was disputed and the methodology criticized by many researchers.

b. *Failure of shape constancy [41]*

Here it is found a failure of shape constancy in their group of children with Autism, which they explained by suggesting that individuals with Autism are less influenced by prior knowledge in visual judgements.

c. *Gestalt perception [38]*

According to Bogdashina [38], autistic people are bombarded by sensory stimuli resulting in sensory information being received in infinite detail and holistically at the same time which is described as ‘gestalt perception’ – perception of the whole scene as a single entity with all the details perceived simultaneously. When too much information needs to be processed simultaneously in Autistic children,

Sensory subtype of autistic child	Characteristics	Possible design interventions
low registration	they miss more cues than others, fail to notice things and respond	Maximize new sensory experiences
sensation seeking	enjoy and create visual sensory experiences and gets distracted with new sensory experiences	Do functional zoning and minimize new sensory experiences that might distract the child in the zones where greater attention is required (learning) and maximize sensory stimuli in other zones
sensation avoiding	notice things much more than others and withdraw when environments are too challenging	Minimize prominent sensory experiences that might make the child withdraw
sensory sensitivity	notice things much more than others and gets upset by stimuli that others might not even notice	Strictly avoid prominent sensory experiences that will upset the child

Table 3: Sensory subtypes in autistic children.

Visual perceptual difference	Possible design solutions
Hyper visual	Minimizing direct lighting and avoiding glare and sharp variations in visual textures
Hypo visual	Maximizing natural and artificial lighting and including reflecting surfaces and contrast in lighting and visual textures

Table 4: Visual sensory difference in Autistic children.

they process only those bits which happen to get their attention referred to as 'fragmented perception'.

d. Deficit in visual form processing [42]

According to Bogdashina and O'Brien, Autistic individuals have a deficit in visual form processing. They used patterns of correlated dot triplets where structured elements were mixed with random ones and found a deficit in visual form processing in Autism [28].

Possible design interventions (Table 5)

Observation Studies and Survey of Caregivers - Inferences

Case studies of ten autistic children done at homes, which included detailed observation study of child as well as questionnaire survey of caregivers, elicited the following inferences - Most of the autistic kids exhibit Insistence on Sameness (IS) and the child insisting on the same setting was observed in majority of the cases. Further it was observed that in the case of older kids, most of the sensory sensitivities have been overcome and the kids have become more manageable which could possibly be due to slow desensitization over years on exposure to real world situations.

Design Interventions for Sensory Comfort of Autistic Children

Overlapping the guidelines for psychological comfort, behavioral impact in children, sensory comfort and visual processing differences in autistic children, specific guidelines were formulated for modifying the design elements. The design matrix and specific guidelines for sensory comfort in autistic children is as follows (Figure 2).

1. Ensure good general lighting (natural and artificial) for the entire space (no flickering lights or dark corners); lighting design for contrasting shadows of design elements/objects; ensure means for unobstructed outside view with due consideration to privacy.

2. Dim indirect artificial lighting and avoid direct sunlight/glare; lighting design for sharp contrasting dark corners; provide options to minimize outside view by providing curtains/blinds.
3. Bright shades of contrasting warm colours are to be used in design; curve the edges of walls and surfaces; add contrasting visual textures including natural looking surface finishes (wood/stone finish), more reflective surfaces (even mirrors), fractal patterns and natural elements (pebbles).
4. Dull shades of contrasting warm colours are to be used in design; curve the edges of walls and surfaces; minimize contrasting visual textures and reflective surfaces but include fractal patterns and natural elements.
5. Echo proof through design elements (cloth curtains, bookcases); provide for sustained low background sound like water features, wind chimes and so on.
6. Reduce noise by acoustical treatment.
7. Provide for prevention of heat gain in the space through appropriate design of transparent (double glazing for fixed windows, shading for openable ones) and opaque (false ceiling for heat from roofs) elements.
8. Provide options for using temperature control systems (mechanical systems).
9. Design for maximum air movement to reduce smells and odors.
10. Incorporate naturally scented objects in design (like flowers, flowering plants or even burning incense).
11. Cut out sources of strong smell from inside/immediate outside by buffers for odour abatement (indoor plants, wood).
12. Rough surface textures and non-slippery floor surfaces.

Visual processing difference	Possible design solution
Lesser susceptibility to visual illusions	Avoid hurdles in the expected pathway for movement of the child to minimize the trouble of figuring out the actual distance from the object Avoid drastic variations in sizes of objects adjacent to each other to minimize the trouble of figuring out spatial relationships
Failure of shape constancy	Use simple geometric shapes (circle, square) to minimize visual confusion
Gestalt perception	Use of predominant edges, use of texture gradient, colour and lighting contrast as cues for figure-ground discrimination
Deficit in visual form processing	Avoid overlap of objects in major view points as these might be perceived not as the simplest form and might cause visual overload

Table 5: The visual processing differences and the possible design solutions.

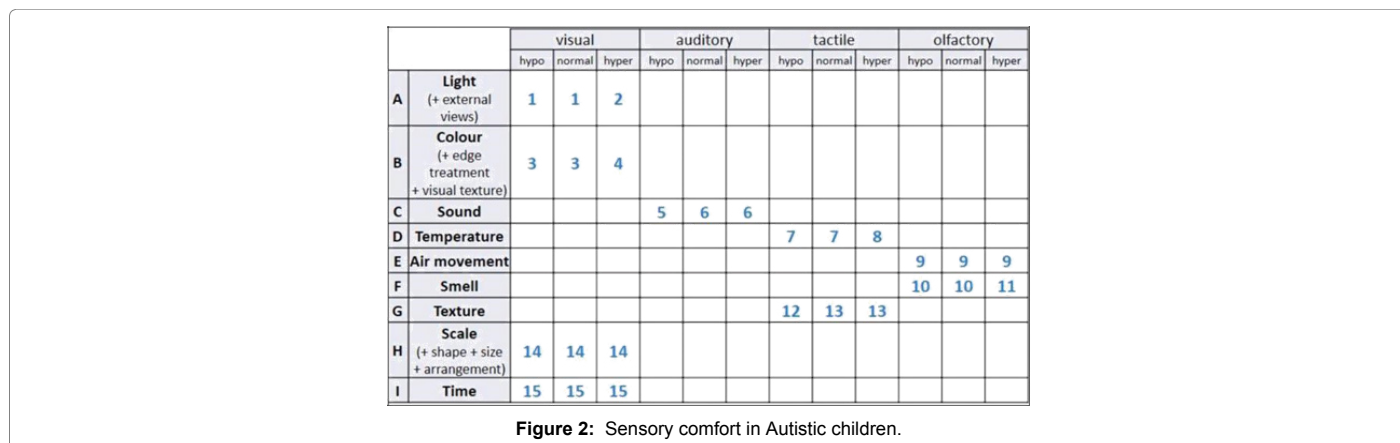


Figure 2: Sensory comfort in Autistic children.

13. Soft and smooth surfaces and non-slippery floor surfaces.
14. Design for human/intimate scale to ensure that the space is controlled for all senses; Use simple geometric shapes (circle, square) and avoid drastic variations in sizes of objects adjacent to each other; design for minimal overlap of objects in major viewpoints.
15. Temporal changes must be incorporated to the design to accommodate the change in perception of the child across time (if a child overcomes sensitivity).

Conclusions and Discussions

Designing for spaces in which the Autistic child could be sensorily comfortable can potentially help management as many of the symptoms could be manifestations of their sensory discomfort. It could possibly reduce parenting stress and can be empirically analyzed through pre intervention and post intervention survey of caregiver stress. The formulated matrix and design guidelines can help in designing comfortable spaces at homes or at an institutional level. But at the same time, the possibility of the child insisting on the same setting cannot be neglected. As to the possibility of further research along this line, the following may be noted. There are existing research studies that conclude that social deprivation influences development of skills that are fundamental for early speech and language development [43]. Reduced social attention will affect a child's social experience; experience shapes brain connectivity and hence the brain changes observed in older children and adults with Autism maybe a result of socially deprived experience [44]. Sensory processing differences interferes with social participation [45], which hinder the ability of autistic children to participate in social interactions [46]. Hence an attempt to overcome the sensory differences at an early age by desensitization/ exposure to spaces designed for sensory discomfort, might help reduce symptoms related to impairment in social interaction and communication in autistic children. There are supporting longitudinal studies proving that the symptom severity in Autism decreases with age [47,48,49] which could possibly be due to slow desensitization over years on exposure to real world situations. And since characterization of the neurobiological alterations that underlie Autism and development of novel therapies require multidisciplinary collaboration [50], cross disciplinary research studies in future can explore whether specific architectural design interventions for sensory discomfort can enhance the neural connectivity in cerebellar regions involved in sensory perception and integration and reduce symptom severity in Autistic children.

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Declaration

It is declared that this is original/unpublished work and only the authors have contributed intellectually to this research.

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