# AN ARCHITECTURE FOR AUTISM: CONCEPTS OF DESIGN INTERVENTION FOR THE AUTISTIC USER

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## Abstract

*One in every 150 children is estimated to fall within the autistic spectrum, regardless of socio-cultural and economic aspects, with a 4:1 prevalence of males over females (ADDM, 2007). Architecture, as a profession, is responsible for creating environments that accommodate the needs of all types of users. Special needs individuals should not be exempt from such accommodation. Despite this high incidence of autism, there are yet to be developed architectural design guidelines catering specifically to the scope of autistic needs.*

*The primary goal of this research is to correct this exclusion by developing a preliminary framework of architectural design guidelines for autism. This will be done through a two phase study. The first phase will determine, through a questionnaire of first hand caregivers of autistic children, the impact of architectural design elements on autistic behaviour, to determine the most influential. The second phase, based on the findings of the first, will test the conclusive highest ranking architectural elements in an intervention study on autistic children in their school environment. Specific behavioural indicators, namely attention span, response time and behavioural temperament, will be tracked to determine each child's progress pre and post intervention, for a control and study group.*

*This study concludes in outlining the findings of both phases of the study, the first being the determination of the most influential architectural design elements on autistic behaviour, according to the sample surveyed. The second group of findings outlines design strategies for autism in three points. The first is the presentation of a "sensory design matrix" which matches architectural elements with autistic sensory issues and is used to generate suggested design guidelines. The second is the presentation of these hypothetical guidelines, two of which are tested in the presented study. These guidelines are presented as possible interventions for further testing. The third is a group of specific design guidelines resultant from the intervention study. It is hoped that these will provide a basis for the further development of autistic specific design standards, and take us one step further towards more conducive environments for autistic individuals.*

## Keywords

Autism; design; architecture; special needs; sensory environment.

## Introduction

The person-environment relationship has long been an integral part of architectural research.

The careful examination of the dynamic between the built environment- with its attributes of acoustics, visual character, spatial quality, color, texture, geometry etc- and human behavior can lead to the development of more specific and sensitive design guidelines. With these more attuned guidelines, designs become more conducive of productivity, efficiency and comfort for all users. Special needs individuals have been given particularly close attention in this type design guideline development. Autism, a developmental disorder which is characterized by delayed communication skills, challenged social interaction, and repetitive behavior, has long been excluded from various architectural guidelines and codes of practice for special needs.

It is the primary objective of this study to remedy this exclusion and take the first step towards developing autistic specific design guidelines. Using an intervention study of a group of autistic students, the impact of the architectural environment on their behavior and development is analyzed. The conclusive analysis of the data collected from this case study provides the catalyst for the development of a framework, or "sensory design matrix", which organizes the complex and dynamic relationship between sensory characteristics of the built environment and the variant spectrum of sensory issues found in autistic users. The conclusive guidelines include specific design criteria which may be used to customize a space for an individual user or a group of autistic users with similar sensory profiles. Less case specific, broader guidelines are also outlined and include concepts such as sensory zoning, use of transition spaces between zones, adoption of escape spaces and the use of visual cues to enhance way-finding. Such guidelines, being based on the "sensory design" concept put forth in this paper, and after further research, may be universally applied to any building type for autistic users, from educational to residential to medical and recreational.

## Architecture and Autism

Recent research has indicated that autism is growing at almost epidemic proportions (Hill & Frith, 2003) and (Fombonne, 2005). Despite its overwhelming incidence, autism is by and large ignored by the architectural community, excluded from building codes and guidelines, even those developed specifically for special needs individuals. In reference to this exclusion Brown of the International Code Council stated

*"I know of no building or accessibility code that incorporates requirements specifically to address children with autism. However, accessibility in general is addressed in the codes developed by the International Code Council."* Brown, L.,(2003), CBO Codes & Standards Development, Technical Staff[1]

The United Nations mandate on the Global Program on Disability also fails to outline specific building standards for autism. Although not legally binding, the Standard Rules on the Equalization of Opportunities for Persons with Disabilities, resolution 48/96 annex of 20/12/1993, presents governments with a moral commitment to provide equal opportunities for persons with disabilities. This covers many issues, including employment, recreation, religion, education and accessibility to public services. The issue of accessibility is of primary concern to architects. No specific references are made in the mandate regarding individuals with developmental disorders or even autism, but the term "consideration" is applied with regards to "other communication disorders" (UN Global Program on Disability, 1993). This has since been reviewed and it has been pointed out that individuals with developmental and psycho-social disorders, of which autism is one, have been overlooked (Al Thani, 2004). Various building codes of practice have also excluded specific requirements for designing for autism. Among these are three documents published by the Department of Education and Employment in the UK (Architects and Building Branch, Department of Education and Employment (1), (2), (3)). The first two documents "Access for Disabled People to School Buildings" and "Designing for Pupils with Special Educational Needs- Special Schools", make no reference to specific guidelines when designing for autistic users, while "Inclusive School Design- Accommodating Pupils with Special Educational Needs and Disabilities in Mainstream Schools" mentions autism in a very limited sense with generic reference to acoustics for special needs. These documents do, however, provide comprehensive guidelines for dealing with other special needs and learning difficulties.

This general exclusion may be a result, in part, of the non-standardized nature of challenges and, respectively, needs along the autistic spectrum. It is the contention of this paper however, that a design strategy to deal with these varying challenges may be put in place allowing a form of customization for groups of users. This strategy will also facilitate the generation of broad design guidelines and policies.

In order to have a better understanding of this disorder, many definitions and theories have been set forth in the past regarding the mechanisms of autism. This paper bases its hypothesis on the sensory definition of autism, put forth by researchers such as Rimland (1964), Delacato (1974) and Anderson (1998). In such theories, autistic behavior is credited to a form of sensory malfunction when assimilating stimulatory information from the surrounding physical environment. It is the conceptual pivot of this research that the architect, through design of this physical sensory environment, has control over the nature of this critical sensory input. By understanding the mechanisms of this disorder and consequent needs of the autistic user, this environment may be designed favorably to alter the sensory input, and perhaps modify the autistic behavior, or at least create an environment conducive of skill development and learning.

The key to such modification is the process of perception. If we look at typical perception as the understanding of, and relevant response to, the sensory input from the surrounding environment, i.e. the architectural design, we can better understand the role of architecture in autistic behavior. Most interventions for autistic individuals, predominantly medical, therapeutic and educational, deal with the sensory malfunction itself and the development of strategies and skills for the autistic individual to use when coping with these malfunctions. It is the contention of this research that autistic behavior can be influenced favorably by altering the sensory environment, i.e. the stimulatory input, resulting from the physical architectural surroundings (color, texture, ventilation, sense of closure, orientation, acoustics etc.) before, rather than after the sensory malfunction occurs. Perhaps by altering this sensory input in a manner designed to accommodate specific autistic needs, behavior may be improved, or at least a more conducive environment created, for more efficient skill development.

Previous architectural research has supported theories regarding the influence of the architectural environment upon user behavior in typical non-autistic users. Deasy and Laswell discuss architect's use of common patterns of cognition to guide and manipulate user behaviour in a space (Deasey & Laswell, 1990). If we look at meaning, or the cognitive value given to an experience, we can understand how a user typically interprets his architectural environment. Lang discusses various mechanisms through which meaning is obtained from the architectural environment (Lang, 1987). Architects utilize this concept in designing space, by giving certain meanings through form, to influence user behaviour. Mostafa discusses the means by which cognitive issues generate architectural patterns in various cultures (Mostafa, 1998). Just as architectural practices adjust themselves to accommodate socio-cultural cognitive patterns this paper proposes similar sensitivity to the very different cognitive patterns of autistic individuals. These patterns are formed through multi-sensory perception and hence deviate from the typical in autism. It is the objective of this paper to understand these patterns through the eyes of autism and develop them into design guidelines, approaches and concepts.

## Methodology

### Study Design- Phase 1

To reach this goal of developing a framework for architectural guidelines for autism, a two phase study was carried out. The first phase of this was a cross-sectional descriptive study of the primary caregivers and teachers of autistic children. The objective of this first phase was to rank the impact of specific architectural factors or spatial characteristics - acoustics, visual (colors and patterns), visual (lighting), texture, olfactory and spatial sequencing of functions. The results from this ranking would indicate the most influential architectural factors on autistic behavior, which would become the intervention variables to be studied in Phase 2.

### Study Tools- Phase 1

The primary tool used for this phase of the study was an online questionnaire posted on the Families for Early Autism Treatment, FEAT, a website dedicated to families and educators of children with autism. This same questionnaire was also distributed to the caregivers and teachers of the Advance Society for Developing Skills of Special Needs Children, Cairo[1]. Participants were asked to rank 5 architectural factors - acoustics, visual (colors & patterns), visual (lighting), texture, olfactory and spatial sequencing of functions, from the most influential to the least.

### Study Sample- Phase 1

A purposeful sample of a total of 83 individuals, with a distribution of 25 teachers and 58 primary caregivers, responded to this questionnaire. Their participation was voluntary. The respondents were both local (Egyptian) and western (Americans). All participants were from the middle to upper strata of the socio-economic middle class.

### Study Design- Phase 2

This second phase is comprised of two interventions, both implemented at the Advance Society for Developing Skills of Special Needs Children in Cairo. Each of these interventions studies an architectural variable, chosen based on the results of the phase 1 survey. These variables are acoustics and spatial sequencing. Both interventions compare the performance of a control and study group.

The first test analyzes the impact of acoustics on autistic behavior in speech and language acquisition. This intervention involved the acoustical modification of a speech and language therapy room through soundproofing of floor, wall and ceiling surfaces with the objective of reducing both echo and external noise penetration. The detailing used for this soundproofing used inexpensive materials requiring minimal installation in order to be cost-effective and reduce the disturbance to the school's operation during such installation. The average background noise level was reduced from 65.5 decibels to 52.5 decibels. The echo ratio was reduced from 96% to 57%. These readings were taken using a standard sound level meter and a 90 decibel sound source. Noise levels were recorded on a grid throughout the room and a numeric average was taken. Echoes were measured against all four walls and again a numeric average ratio was taken (Kuttriff, H., 1991).

The second intervention dealt with spatial sequencing. This involved reorganizing the spatial layout of one of the school's classrooms, in such a way that promoted routine. This was achieved through the organization of the functional spaces of the classroom, within which a single activity is carried out, into "stations" or separate defined zones, including an "escape space" which acted as a haven for times of sensory imbalance in the children (fig. 1). This scenario was based on the long-standing hypothesis that autistic children adhere to routine (Kanner, L. 1943), (Medical World News, 1966), a compulsion which is an integral diagnostic indicator of autism (Schopler et al, 1988). This resistance to change is commonly viewed as a problem in autism, but it is hoped that by capitalizing on this otherwise negative characteristic, positive changes can be made. By creating a predictable environment in the learning space and catering to the child's need for routine, he or she may be more open to learning essential skills that can be generalized outside this controlled space, making him or her ultimately less dependant on the routine.

This design approach of compartmentalization also confines the limits of the sensory environment with which the child interacts during any given activity or 'station'. The physical compartmentalization of activities also helps decrease visual distractions, and limits fields of peripheral vision. These issues normally add to the distractibility of the child and limit his attention span. It is theorized that by limiting these visual and other sensory issues, the child will learn to focus on the educational task at hand. Ultimately the visual and auditory cues of the activity will condition the child and help him generalize his responses outside the controlled environment.

Some may argue that the real world is not setup in clearly defined "stations" and very frequently 'routine' is disrupted. This is a very realistic and relevant observation, but it is hoped that such a configuration within the classroom will help develop skills to deal with such chaos, disorganization and unpredictability.

Figure 1: Plan of compartmentalized study classroom showing simultaneous use of various stations. (Source: Author).

## Study Tools- Phase 2

The study technique used for both interventions, acoustical modification and spatial sequence compartmentalization, was the progress observation of specific behavioral indicators. These indicators were attention span, response time and behavioral temperament. The rationale behind the choice of these indicators is their inherent role in skill development for all individuals, but particularly autism, where they play a fundamental role in skill acquisition and development. Since it is the ultimate goal of this research to outline strategies to create environments more conducive of learning, these behavioral indicators must be addressed. It is hoped that by creating an environment where the autistic child is more focused and less prone to behavioral outbursts, an educational window of opportunity will be generated, and more efficient skill development will be achieved in a shorter period of time. This sort of approach is fundamental in outweighing the developmental delay of the autistic child.

Direct observations, by the researcher and teachers, as well as video, were the tools used to measure and record the indicators. In the case of attention span, defined as the amount of time in seconds the child remains on task without distraction, a longer attention span indicates a positive result. With regards to response time, defined as the amount of time in seconds it takes for the child to respond to a command or question, a shorter response time indicates a positive result. Behavioral temperament was indicated by measuring the occurrence of self-stimulatory behavior. This behavior is a habitual, compulsive action exhibited by the autistic child, indicative of discomfort and sensory imbalance. Unique to each child, this may range from head banging to hand-biting to rocking etc. It has been shown that such behavior, when decreased, indicates a successful outcome of the intervention (Kaplan et al, 2006).

The total time period of these tests was one academic year, the first semester being used for baseline documentation to benchmark each individual child's progress, as well as to allow the children to familiarize themselves with the presence of the researcher on the premises during observations. The second semester was used to document the impact of the test scenarios on the study group and control group. For each of these indicators, during this second semester, readings were taken at specific milestones during a total span of 12 weeks, from February to June 2003, at week 0, week 4, week 8 and week12. Each reading was taken during one 45 minute class period. In the case of attention span and response time, an average time was calculated for the week. In the case of behavioral temperament an average occurrence rate of self-stimulatory behavior during one class period was calculated for each week.

Behavioral mapping was also used as an additional qualitative tool, to internally validate the findings. This tool outlined behavioral patterns and their relationship to use of space (Sanoff, H., 1991). Such patterns were documented at milestones parallel to the other readings: week 0, week 4, week 8 and week12. The observational data collected from this tool helped translate the abstract data recorded into workable architectural guidelines. To produce the behavioral map, each child was observed for a five minute interval, or vignette, in the altered space. His responses, movements and activities were documented as an annotated diagram on the layout as well as in a time-line chart (fig. 2). This technique was only used for the spatial reorganization test scenario as the acoustical modification scenario did not have a spatial sequence element.

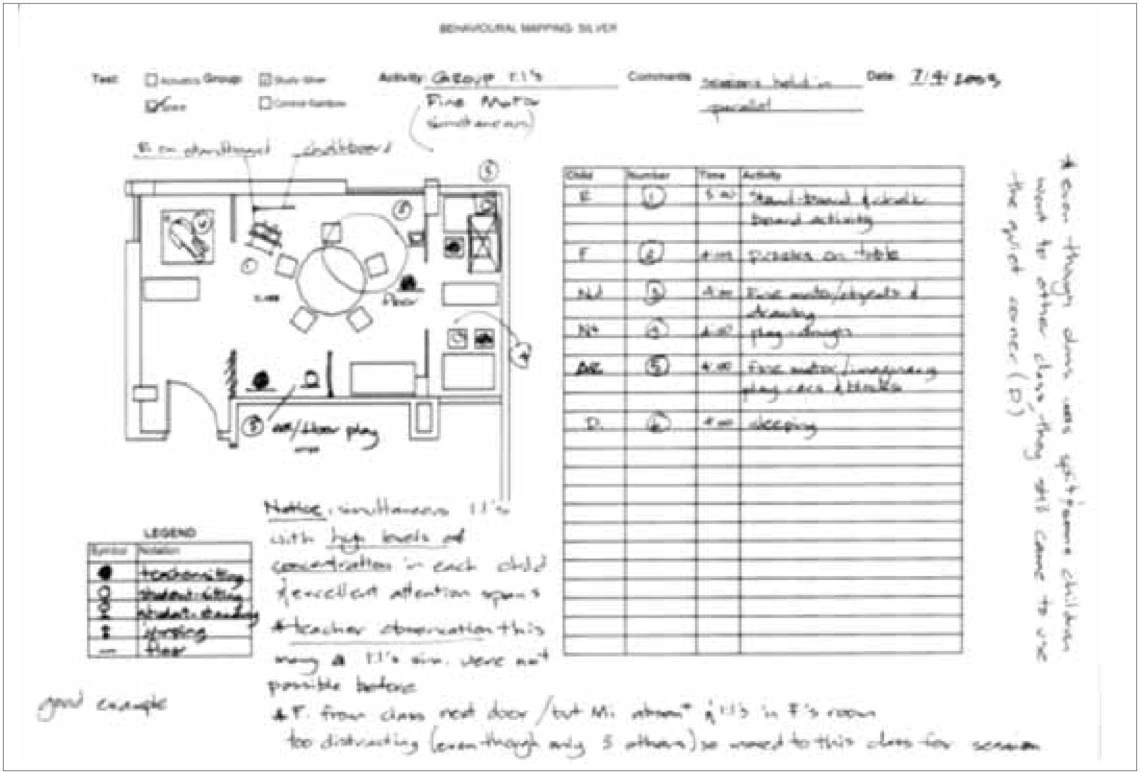

Figure 2: Behavioral map of study classroom showing annotated diagramming and time chart. (Source: Author)

### Study Sample- Phase 2

Both interventions use a comparative study group vs. control group format. Special needs classes, particularly those for autistic children are small, with a teacher to child ratio reaching 1:1 in some cases. One study class and one control class, out of a total of 8 classes in the center, participated in the study, with 6 students in each class, making a total sample size of 12 students, representing 25% of the student body.

The classes chosen for intervention were from the primary level classes, given that their early age makes them most impressionable and indicative of intervention impact. These classes are grouped based mainly on skill and ability rather than age alone. The ages of the students participating in the study therefore ranged from 6-10 years, with a mean age of 8.33 years and standard deviation of 1.63 and median of 8.5 in the study group, and a mean age of 7.5 years with a standard deviation of 1.643 and median of 7 in the control group. Given the natural tendency of higher occurrence of autism in boys over girls the ratio of males to females in the study was 9:3.

Due to the heterogeneity of the sample and the fact that skills vary from child to child, results were analyzed relatively, with regards to each child's respective performance, rather than absolutely, across the entire sample. Friedman testing was used for the multiple progress readings of attention span and response time while Wilcoxon Signed Rank Testing was used for the pre and post progress readings of behavioral temperament.

## Ethical Considerations

Given the sensitive nature of this study, and the confidentiality issues involved, particularly with respect to the young age of the children and the adopted tools of video, consent from the primary caregivers of the children was essential. A written consent form, outlining the goal, structure and projected outcomes of the study, was distributed to all the parents and legal guardians of the children participating in the study, requesting their permission for three aspects. The first aspect was the inclusion of the child in the study, the second was access to the child's clinical and academic file, and the third was permission to record the child's progress throughout the study. Separate consent was requested for videotaping and photography. The wishes of all parents regarding the degree and type of involvement of their children were unequivocally respected.

## Results and Discussion

The overall results of this study show promising indications of the possible improvement of autistic behaviour, as indicated by increased attention span, reduced response time and improved behavioural temperament, using an altered architectural environment. These indicators, when combined, create a behavioural environment more conducive of learning and may increase the autistic child's opportunity for skill acquisition and development. This also indicates the preliminary success of acoustical control and spatial sequencing as architectural guidelines conducive of positive autistic behaviour.

Despite the heterogeneity of the sample population, as well as the small sample size, statistically significant results, as calculated using the Mann-Whitney test, support these preliminary findings in most cases, as indicated by a significance lower than 0.05.

This study should hence be considered a first stage exploratory study, intended to judge preliminary influence of the test variables on autistic behaviour as measured by the test indicators. It is therefore recommended that further studies, using randomized testing with a larger sample size and standardized possible confounder factors, be conducted to verify its preliminary findings.

## Phase 1- Architectural Influence on Autistic Behavior

The results of this phase show that, according to the sample surveyed, acoustics are the most influential architectural factor on autistic behavior, followed by spatial sequencing. According to the results of the questionnaire 64% of teachers and 79.3% of parents rank acoustics, and 20% of teachers and 13.79% of parents rank spatial sequencing as the most influential architectural factor on autistic behavior. Other factors such as visual (lighting), visual (colors and patterns), texture and olfactory issues were given less influential importance by the sample surveyed. Percentage of teachers ranking these factors as highest were 8%, 4%, 4% and 0% respectively, while percentage of parents were 3.45%, 0%, 1.72% and 0% respectively. These results formed the basis for choice variables for the experimental testing of Phase 2, concluding acoustics and spatial sequencing as appropriate interventions for experimental testing.

## Phase 2- Acoustical Modification Test

<u>Attention Span:</u>
The results of this intervention indicate positive improvement in attention span of the study group students. The children were better able to identify, recognize, imitate and verbalize in the soundproofed speech room. On average the study group exhibited an increase of more than 3 times their original attention spans. They exhibited a gradual increase in their attention span median from 44 to 58 to 72 to 142.50 seconds over the 12 week period. The mean of the group progressed gradually from 45 to 130.5 seconds with standard deviations of 27.07 and 34.61 respectively.

The control group did not exhibit similar gradual progress. There was no distinct pattern of improvement in their attention spans whose median progressed from 38 to28 to 22 to 27 seconds over the 12 week period. The mean of the group moved from 38.67 to 27.33 to 27.83 to 27.33 with standard deviations of 17.69, 17.1, 22.09 and 8.26 respectively.

The statistical significance of these results were verified using the Mann-Whitney test and ranged in exact significance from 0.818, 0.026, 0.009 and 0.002 respectively over the 12 week period.

The Friedman rank testing results of this data also shows significant relative progress of each individual student over time in the study group, with a gradual increase in mean ranking from 1.33 to 2.17 to 2.50 to 4.0 through weeks 0-12, with an asymptotic significance of 0.004. Friedman rank testing of the control group shows little relative improvement of each individual student with mean ranks of 3, 2.17, 2.33 and 2.5 through weeks 0-12, with an asymptotic significance of 0.7060.

<u>Response Time:</u>
With regards to response time, promising indications were also observed. The students of the study group were seen to respond faster and were able to sustain that quick response more frequently and for longer periods of time. During the span of the trial, students from the study group illustrated a gradual decrease in their response times, indicating a positive result. Their median response times decreased from 25.50 to 16 to 10.50 to 7.00 seconds through weeks 0, 4, 8 and 12 respectively. Their mean responses decreased gradually from 24.83 to 6.83 seconds with standard deviations of 12.92 and 5.08 over the same period of time.

Again the control group did not exhibit such uniform progress. Their median response time progressed from 9 to 8 to 9.5 to 12 seconds through weeks 0-12, showing no distinct pattern of improvement, but rather general consistency. Their mean response times were 10.3, 7.17, 9.67 and 11.66 seconds with standard deviations of 3.14, 3.54, 3.83 and 4.23 respectively through weeks 0-12.

The Mann-Whitney exact significance scores of these results were 0.065, 0.132, 0.818 and 0.093 respectively over the 12 week period.

Regarding individual relative progress of cases Friedman rank testing of response time progress for the study group is also promising, showing a gradual decrease in mean rank from 3.83 to 2.5 to 1.92 to 1.75 during the study period, with an asymptotic significance of 0.02. Again the control group did not display similar regularity in progress. The control group's response time mean ranks were 3.08, 1.25, 2.25 and 3.42 with an asymptotic significance of 0.009.

<u>Behavioural Temperament:</u>
The behavioural temperament of the study group students was also seen to improve, with the median occurrence of self-stimulatory behaviour in the study group decreasing from 2.5 to 1 occurrence, compared to a stable median of 2 occurrences in the control group, pre and post intervention at weeks 0 and 12. The mean occurrence in the study group was decreased from 3.33 to 1.17 with a standard deviation of 2.66 and 1.17 respectively, pre and post intervention. The control group showed little change with a mean of 2.17 and 2.5 occurrences, pre and post intervention, with standard deviations of 1.17 and 2.17 respectively.

Given the pre and post reading format of behavioural temperament the Wilcoxon signed rank test was used to determine individual case performance over time. 5 out of 6 of the study students showed negative ranks, indicating a post-intervention occurrence of self-stimulatory behaviour less than the pre-intervention occurrence, i.e. an improvement in behavioural temperament. One tie rank was also observed. These results had an asymptotic significance of 0.041. With regards to the control group, only 2 out of the 6 displayed a decrease in occurrence or negative ranking, with 3 exhibiting positive ranking, or increase in occurrence of self-stimulatory behaviour, and 1 tie. The asymptotic significance of this reading was 0.480.

## Phase 2- Spatial Sequence Intervention

Similarly promising results were observed in the second intervention which involved the study of the impact of spatial sequencing, or compartmentalization, on the test indicators.

<u>Attention Span:</u>
In tracking the progress of attention span in the study group after implementation of the spatial sequence intervention, a general pattern of improvement was observed. The median attention span dipped at first and then gradually increased from 13.5 to 12.5 to 22 to 30 seconds from week 0 through12. The mean attention span was 18, 17.83, 34 and 44 seconds with standard deviations of 12.7, 13.11, 26.01 and 28.85 over the same period. A similar pattern of gradual improvement was not observed in the control group. Median attention span in the control group went from 39.5 to 25 to 28 to 25.5 seconds from week 0-12. These results had an exact significance of 0.093, 0.132, 0.818 and 0.485 through week 0-12.

In tracking individual case relative progress, this intervention's Friedman rank testing results showed a preliminary plateau, then gradual increase throughout the study period, in mean ranking of the study group from 1.5, to 1.5 to 3.33 to 3.67 with an asymptotic significance of 0.002. A similar pattern was not found in the control group which had a mean ranking of 3.5 to 2.33 to 1.83 to 2.33 from week 0-12, with an asymptotic significance of 0.145.

Response Time:

Response time was also seen to be improved as a result of the compartmentalization and spatial sequencing of the classroom. The study group exhibited a decrease, i.e. improvement, in median response time from 11 to 8.5 to 6.5 to 3.5 seconds during week 0, 4, 8 and 12 respectively. Their mean response times over the same period were 18.33, 8.67, 8.5 and 4.17 seconds with standard deviations of 21.21, 4.32, 6.92 and 3.19.

The control group again showed no regular pattern of increase of decrease. Their median response times were 11, 7.5, 17 and 12.5 seconds from weeks 0-12. Their mean response time was 12.33, 8.5, 23 and 12.17 seconds with a standard deviation of 8.59, 3.39, 20.02 and 4.02, over the same period of time. The asymptotic significance of these results was 0.937, 0.937, 0.093 and 0.009 from weeks 0-12 respectively.

The individual relative progress of students in the study group exhibit similar patterns of improvement. The Friedman rank testing results of the study group show a gradual decrease in mean rank from 3.67 to 2.58 to 2.67 to 1.08 with an asymptotic significance of 0.006. Again, although the individual performance reflects the group pattern, or lack thereof, there seems to be no distinct pattern of improvement or regression in the control group. Their mean rank progresses from 2.33 to 1.5 to 3.42 to 2.75 through weeks 0-12 with and asymptotic significance of 0.07.

Behavioral Temperament:

Again, behavioral temperament of the study group was seen to improve, although not as significantly as the other indicators. The median occurrence of self-stimulatory behavior in the study group decreased from 1.5 to 0.5 occurrences, with a mean of 2.83 and 1.33 with corresponding standard deviations of 3.54 and 1.75, all pre and post intervention at week 0 and week 12. The control group didn't show similar significant improvement, with a median occurrence of 1 and 1.5, pre and post intervention, and mean occurrence of 0.83 and 1.50 with corresponding standard deviations of 0.76 and 1.05. The exact significance of these results was 0.485 and 0.699 at week 0 and week 12 respectively.

Individual progress of cases parallels the results of the groups. Again using Wilcoxon signed rank testing 4 out of 6 students from the study group showed negative ranks, or a decrease in self-stimulatory behavior, with 0 positive ranks and 2 ties. The control group did not exhibit similar progress with only 1 student out of 6 showing negative ranking, or a decrease in self-stimulatory behavior, and 3 students showing positive ranking, or an increase, with 2 ties. The asymptotic significance of this is 0.194.

Observational Results of Behavioral Mapping:

Many interesting observations were recorded regarding the behavioural use of space throughout the duration of the spatial sequence test. One of the very first observations made early on in the test was the effect of the "escape space" upon the behaviour of the children, particularly the hyperactive and severely autistic ones. Prior to the modifications, one such child with complex auditory, tactile and proprioceptive issues, was constantly removing herself from the group to sit on the floor against a wall with legs stretched in front, banging her head against them. This would usually last for about 10 minutes, after which she would sit quietly alone for a few minutes and then rejoin the group. The child was apparently escaping the maladjusted sensory stimulation of the session at hand and re-calibrating her inner sensory mechanism. She first removed herself from the situation and then provided herself with the sensory input required: auditory reduction by distancing herself, tactile by inflicting pain, and proprioceptive through the rhythmic movement and physical boundary of the wall.

Once an escape space was made available, where no other activity was conducted, both teachers and the researcher expected this child to spend the majority of her time within it. At the very beginning, that was the case, but eventually the child used the space less and less. It was observed, however that she constantly looked over her shoulder, checking to make sure it was still available. She became slightly more focused, if anything only because of the diminished number of "escapes". It was almost as if the mere presence of the option to escape was sufficient, and her need to escape decreased, now that she was comfortable with the fact that there was constancy in that escape opportunity.

In the control class, with the absence of a formal and partitioned escape space, similar effects were not observed. Those children who did need time-out used a cushion in the corner but were constantly either disturbed by their curious peers, or joined by them. Either way, both the individual child's escape time, as well as the session, was disrupted. Although there was a partitioned area in the class, it was arranged for one to one instruction, with distractions and sensory stimulus incongruent with a true 'escape'.

Another apparent positive influence observed was the effect of the compartmentalization upon the visual distraction of the children. Many of the hyper-visual and even hyper-auditory children would look up, becoming distracted from their work, if anyone moved around or entered the room. Since regaining the attention of an autistic child, once distracted, can be difficult, this was a major problem. The design modification, however, with its physical and visual compartments, influenced this positively. In the new layout, the children were always situated so that visual accessibility would be minimized, particularly during their one to one sessions where focus was a priority, and, unlike group sessions, outside interaction was to be minimized (fig. 1). When the child heard a sound or saw something move in his peripheral vision, he would look up, as before, but in this case be unable to see above and around the partitions. Eventually the child became conditioned not to look up. He became more attentive and focused with this decrease in distraction. With the repetition of this exercise he may learn to transfer the sense of focus and associate it with the activity at hand. Hopefully such a skill can eventually be generalized to other spaces, where such visual accessibility is not controlled. Again the control group, with the absence of the physical and visual boundaries, did not develop this conditioning.

Spatial efficiency was a further positive observation made in the study class. Due to the segmented and compartmentalized nature of the new classroom layout, the available space was used much more efficiently. The level of activity achieved in the new layout was not possible prior to the modifications. Previously, the teachers found it far too distracting for the children to conduct merely three one to one sessions concurrently. After the spatial reorganization, three one to one's, a group table session, a floor play session and a napping student in the escape space were all comfortably and attentively using the space at once.

During such a session it was noted that the general attentiveness of the children, as well as their temperament, was above average, despite the fact that each child was involved in a different activity. Apparently the physical and visual boundaries of the various compartments help provide limits, and with these a certain level of control. In an autistic child the smallest of environments may seem vast as his senses, with their various sensitivities, are being constantly over or under-stimulated. It was observed that by limiting the extents of this environment, both physically and visually, and adjusting its sensory components, for a certain period of time, it allowed the child to remain focused on the activity at hand. This created the ever-important window of opportunity for skill development.

This observation was, perhaps, the most clearly absent in the control group. Despite having a small number of children, it was observed that on many occasions it became impossible to work as a group with even a single one to one session in parallel. The one to one children were constantly being removed from the class to use another empty class or even office for their sessions.

The concept of generalizing behaviour learnt in the classroom is an important one in autistic education. The altered spatial organization of the test classroom was observed to facilitate the first stage of this process. As the child enters the partitioned area, the equipment, furniture and teacher are always arranged in a certain fashion for each activity, triggering a sort of predictability. Prior to the test modifications, similar arrangements were used. The new spatial organization, however, seems to have amplified the “predictability” factor. When a child sees the arrangement, coupled with the physical and visual boundaries of the compartment, he can predict what activity will take place. It is such predictability that autistic children seek through their adherence to routines. When the child is able to expect what will come from his otherwise highly unpredictable environment, he settles. Capitalizing on this is a helpful tool to help calm them and allow them to focus. This new arrangement apparently created just this opportunity.

In the case of the control group there was no spatial compartmentalization to amplify this predictability, even with the use of familiar arrangements. Children were observed to take a few minutes from the beginning of each session to orient themselves to the arrangement and task at hand. This wasted precious time that was available to those children of the study group who had this spatial facilitation.

## Recommendations and Conclusions

As outlined in the above discussion, both interventions seem to have positive implications on the test indicators measured in this study. These preliminary findings can now be translated into architectural tools and guidelines. Much testing is still required before the interventions tested here may be generalized to all environments designed for autism. This study, however, will present a tool to organize the generation of guidelines for further testing, as well as present a group of suggested guidelines, resultant from the study.

The conclusions of this research are outlined in a series of findings and recommendations. The first finding is the result of the preliminary cross-sectional descriptive study which determines the highest ranking of architectural factors influencing autistic behaviour as acoustics and spatial sequence, according to the sample surveyed.

The second group involves the outline for a design tool and its resultant guidelines. This tool, a "sensory design matrix", helps organize the dynamic relationship between the architectural environment and the complex range of autistic sensory issues. (see appendix A).

Since autism presents a large scope of symptoms, each autistic individual has their own group of needs. According to Delecato's (1974) original theories, these needs are derived from each different sensory issue, from the hyper, hypo to white noise interference manifestations. Although impossible to customize a public environment, like a school, to each user, grouping of students with similar needs is possible. An organizational tool matching the various autistic sensory needs represented in the horizontal axis of the matrix, with their appropriate architectural treatment represented by the vertical axis of the matrix, has been developed by the researcher for this purpose. In this sensory design matrix, each architectural attribute, such as proportion, scale, symmetry, color, lighting and texture, is analyzed with respect to its capacity to respond to the various autistic sensory needs. This generates a number of architectural treatments or guidelines, like the acoustical modification and spatial sequencing tested here, which are shaded in the matrix. This matrix also generates a further group of treatments to be considered for use in autistic design, and which can be the basis for further research and intervention tests similar to the ones presented in this paper, in the future.

This design tool acts as an architectural guideline generator, where the users needs are input as a sensory profile and a group of architectural guidelines are matched for each individual user in customized environments such as homes, or groups of users in public buildings such as schools and academic centers. (see appendix B).

Additionally, design recommendations generated from the results and observations of this research may be summarized as follows. These are recommended guidelines to be used by architects designing environments for autistic users.

The application of noise and echo treatment in areas such as speech rooms, although its application may be beneficial in almost all spaces used for autistic instruction and particularly in those where long attention spans, quick responses and high levels of focus are required. Such spaces could include computer rooms, one to one instruction rooms, sensory integration and neurological organization rooms.

The creation of a graduated series of acoustically modified rooms for speech therapy as well as other activities requiring similar acoustical environments. This is to avoid the 'greenhouse' effect, where a child becomes dependant upon the optimum acoustical quality of the room and is unable to function and generalize his skills outside of it. This graduated series would allow the child to use the fully soundproofed room during the critical stage of his autism, when such an intervention may be the only way to initiate communication. Having mastered a fundamental group of communications skills the child should then be moved to a moderately sound-proofed room where he will begin to develop background noise filtration skills. This should continue through the series of available rooms with the ultimate objective of functioning in as acoustically normal an environment as possible.

The creation of an 'escape space' in learning spaces. The sensory make-up of the space should also be well designed. In general it seems best to design a baseline neutral sensory environment, as if designing for the hyper-sensitive across the entire spectrum. Elements of sensory stimulus can then be added to compensate for those hypo-sensitive individuals, by being made available to those who need them. This concept is based on the idea that it is easier to add stimulation from an external temporary source, like a piece of sandpaper for the hypo-tactile, or a moving mobile for the hypo-visual, or music for the hypo-auditory, than to remove stimulation from the environment, like soundproofing for the hyper-auditory, or changing textures for the hyper-tactile.

Just as escape spaces need to be conducive of the activity of 'escape' all other areas in the classroom should be designed with each activity to be conducted in them in mind. A group of facilitative furniture arrangements for various educational activities was developed during the course of this research. As observed previously, the consistency of these arrangements also provides visual cues to condition the child to expect and settle easily to the task at hand.

Such conducive arrangements, and the creation of visual cues, could have particular impact when coupled with compartmentalization. Such compartmentalization capitalizes upon the autistic adherence to, and preference of, routine. This routine theory was shown to be successful in the "a place for everything and everything in its place" concept applied through the compartmentalization of the study group classroom. As seen such compartmentalization limits the sensory environment which the child has to assimilate. It has been shown to promote focus and concentration.

This theory may be extended to encompass the sequencing of activities and functions from inside the classroom to the building as a whole. This would involve developing designs emphasizing order, sequence and routine. Activities could be arranged to follow a sort of 'one-way' circulation arrangement, according to the daily schedule. Different activities could be clearly visually and spatially defined. Universal or multifunctional spaces, such as 'open-plan' classrooms, should be avoided to reduce sensory confusion. This sensory coherence could help student temperament, improving overall performance and economizing on precious time while getting to and from classes, as well as reducing the need to allow calming down time and effort at the beginning of each session.

This discussion brings us to conclude that the autistic user identifies the architectural environment around him or her in accordance to sensory zoning rather than conventional functional zoning. Spatial groupings could follow autistic logic and involve sensorial compatible functions. These groupings can be accessed through a one-way circulation system, emphasizing, as well as capitalizing on, routine, as discussed previously. For example high-stimulus functions like music, art, crafts and psychomotor therapy, requiring a high level of alertness can be grouped together, while low-stimulus functions like speech therapy, one to one instruction and general classrooms, requiring a high level of focus, can be grouped together. Services, which are usually high-stimulus, including bathrooms, kitchens, staff-rooms and administration, should be separated. Only those requiring student accesses should be grouped near the high-stimulus zones and as far as possible from the low-stimulus zones.

The application of the concept of sensory zoning could also reduce the problems of distraction and diversion. Keeping the sensory atmosphere of each area as coherent as possible, could allow a more continuous circulation from one space to another. Through the preliminary structured interviews conducted during this research, it seemed that when the autistic child veers off course when moving from one space to another it is not a question of getting lost but rather a question of being distracted along the way. Some parents and teachers even found the visual recollection skills of their children to provide them with an excellent basis for navigation. It was their distractibility by the surrounding sensory environment that prevented them from reaching their destination. Sensory atmospheric coherence through design may help to reduce this distraction.

When moving to or from an area of high sensory stimulus, the use of sensory "transition zones", in the form of gardens or sensory curriculum areas, may help to prepare the child for such a move with minimal distraction. It is hoped that such an arrangement would allow the child a form of sensory calibration, in order to make the transition from these varying sensory zones more fluid hence allowing improvement of navigational skills.

These concepts of zoning and circulation may be enforced and enhanced using visual cues. As Peeters (1997, p. 63) has shown, such cues have a powerful associative and communicative effect on autistic perception. Even from a first-hand perspective, Grandin (1996) based her explanation of autism on the concept of 'thinking in pictures'. Patterns, colors or abstractions may be used to communicate to the children the character of various zones and spaces. Visually distinctive landmarks may be used at the hub of each zone, indicative of its character. A similar visual concept may be used for signage throughout any autistic facility.

This would serve two purposes, first, comfort to the child allowing him a commonly lacking sense of orientation, and second ultimately allowing him ability to navigate these spaces independently.

In closing it is this idea of independence that is the pivotal concept of facilitating and improving quality of life for all special needs individuals, but for autism particularly. As the first step towards inclusion and acceptance, independence represents an important goal in all autistic interventions. With further research and testing of the guidelines outlined in this study it is hoped that this paper will take us one more step towards achieving that goal. Environments based on careful scientific analysis will benefit not only those with special needs, but all user types, making our architecture more genuinely responsive to all our range of needs.

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Appendix A: Sensory Design Matrix

| ARCHITECTURAL ATTRIBUTE | | Sensory Issues | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Auditory | | | Visual | | | Tactile | | | Olfactory | | | Proprioceptive | | |
| | | a | b | c | a | b | c | a | b | c | a | b | c | a | b | c |
| Structure | A | 1 | 2 | | 1 | 2 | 1 | 2 | 1 | | 1 | 2 | | 2 | 1 | 1 |
| | B | 3 | 4 | 3 | 3 | 4 | | | | | | | | 4 | 3 | |
| | C | 5 | 6 | 5 | 5 | 6 | 5 | 6 | 5 | | | | | 6 | 5 | 5 |
| | D | | | | | 7 | | | | | | | | | 7 | 7 |
| | E | 8 | | | 8 | | | | | | | | | | 8 | 8 |
| Balance | F | 9 | 10 | | 9 | 10 | 9 | | | | | | | 9 | 10 | 9 |
| | G | | | | | 11 | | | | | | | | | 11 | 11 |
| | H | | | | 12 | 13 | 13 | 12 | | | | | | | 13 | 13 |
| | I | | | | 14 | 15 | 14 | | | | | | | 14 | | 14 |
| Quality | J | | | | 17 | 16 | | | 18 | | | | | | | |
| | K | 19 | | | 19 | 20 | | | | | | | | | | |
| | L | **21** | **21** | **21** | | | | | | | | | | | | |
| | M | | 22 | | | | | 22 | 23 | | | | | | | |
| | N | | | | | | | | | | 24 | 25 | 24 | | | |
| Dynamic | O | | | | **26** | **26** | **26** | | **26** | | | | | | **26** | **26** |
| | P | | | | **27** | | **27** | | | | | | | | **27** | **27** |
| | Q | **28** | | | **28** | | **28** | | | | | | | | **28** | **28** |

Sensory Issues
a. Hyper b. Hypo c. Interference

Architectural Attributes

A. Closure
B. Proportion
C. Scale
D. Orientation
E. Focus
F. Symmetry
G. Rhythm
H. Harmony
I. Balance
J. Color
K. Lighting
L. Acoustics
M. Texture
N. Ventilation
O. Sequence
P. Proximity
Q. Routine

Appendix B: Architectural Design Guidelines generated by the Sensory Design Matrix

| # | Design Guideline | Suggested Objective and User |
|---|---|---|
| 1. | **High enclosure and containment** | 1) to reduce external visual and acoustical distraction for the hyper-auditory and hyper-visual<br>2) to provide tactile stimulation via tight spaces and containment for the hypo-tactile<br>3) to create visual focus in cases of visual interference<br>4) to reduce olfactory intrusion via ventilation for the hyper-olfactory |
| 2. | **Low enclosure and openess** | 1) to increase opportunities for acoustical stimulation for the hypo-auditory<br>2) to provide visual stimulation for the hypo-visual<br>3) to reduce sense of containment for the hyper-tactile |
| 3. | **Low ceilings and moderate proportions** | 1) to reduce echoes for the hyper-auditory<br>2) to reduce visual distortion and illusions of space for the hyper-visual<br>3) to promote balance for the hypo and interference-proprioceptive<br>4) to create a more acoustically controllable environment for the interference |
| 4. | **High ceilings and exaggerated proportions** | 1) to increase echoes and auditory stimulation for the hypo-auditory<br>2) to create visual illusionary stimulation for the hypo-visual<br>3) to stimulate the proprioceptive sense of space for the hyper-proprioceptive auditory |
| 5. | **Use of intimate scale** | 1) to reduce echoes for the hyper-auditory<br>2) to create a controllable auditory environment for the interference auditory<br>3) to create a controllable and manageable space for the hyper and interference visual<br>4) to increase tactile stimulation from boundary proximity for the hypo-tactile<br>5) to increase proprioceptive stimulation from boundary proximity for the hypo-proprioceptive<br>6) to create a controllable environment for the interference auditory and proprioceptive |
| 6. | **Use of open scale** | 1) to create auditory stimulation through echoes for the hypo-auditory<br>2) to create visual stimulation through spatial exapnse for the hypo-visual<br>3) to relieve over stimulation from spatial boundaries for the hyper-tactile and hyper-proprioceptive |
| 7. | **Orientation towards external views and elements of interest** | 1) to create focus and attraction for the hypo-visual<br>2) to instill balance and direction for the hypo-proprioceptive |

Appendix B: Architectural Design Guidelines generated by the Sensory Design Matrix

| | | |
|---|---|---|
| 8. | **Use of activity focus to organize space** | 1) to increase attention span and reduce distractibility for the hyper-auditory and visual<br>2) to create a behavioural and geometric point of reference for the hypo and interference proprioceptive |
| 9. | **Symmetrical organization** | 1) creates predictability for the hyper-visual<br>2) creates acoustical balance for the hyper-auditory<br>3) increases sense of centre and balance for the hypo and interference proprioceptive<br>4) creates a controllable environment for the interference visual |
| 10. | **Asymmetrical organization** | 1) creates auditory and visual stimulation for the hypo-auditory and visual<br>2) creates proprioceptive stimulation for the hypo-proprioceptiveTables |
| 11. | **Use of visual or spatial rhythm** | 1) to create visual stimulation and tracking opportunities for the hypo-visual<br>2) to create predictability and coherence to the spatial environment for the hypo and interference |
| 12. | **Visually harmonious space with no contrast or discord** | 1) to create a visually neutral space for the hyper-visual<br>2) to create a neutral tactile space for the hyper-tactile |
| 13. | **Visually unharmonious space using accents and contrasts** | 1) to create visual stimulation for the hypo and interference visual<br>2) to create proprioceptive stimulation for the interference and hypo-proprioceptive |
| 14. | **Use of dynamic and statically balanced spaces** | 1) to create orientation and stability for the hyper-proprioceptive and visual as well as the interference proprioceptive and visual |
| 15. | **Use of unbalanced spaces** | 1) to create visual stimulation for the hypo-visual |
| 16. | **Use of bright colours** | 1) to create visual stimulation for the hypo-visual |
| 17. | **Use of nuetral colours** | 1) to create serenity for the hyper-visual |
| 18. | **Use of warm colours** | 1) to create psychological warmth for the hypo-tactile |
| 19. | **Indirect natural lighting** | 1) minimize glare and distracting views for the hyper-visual<br>2) less distracting than buzzing artificial light for the hyper-auditory |
| 20. | **Direct natural lighting and views** | 1) creates visual stimulation for the hypo-visual |
| 21. | **Noise and echo-proofing** | 1) creates a conducive environment for the hyper-auditory<br>2) removes the distracting opportunity of self-stimulation through echoes for the hypo-auditory<br>3) creates a neutral auditory background for the interference auditory |

Appendix B: Architectural Design Guidelines generated by the Sensory Design Matrix

| | | |
|---|---|---|
| 22. | **Use of smooth textures** | 1) calms the hypo-tactile<br>2) creates echo and reverberation stimulation for the hypo-auditory |
| 23. | **Use of rough textures** | 1) stimulates the hypo-tactile |
| 24. | **Cross-ventilation** | 1) redues smells and odours for the hyper-olfactory |
| 25. | **Enclosed ventilation** | 1) may help contain scents during aromatherapy for the hypo-olfactory |
| 26. | **Organized compartmentalization using visual cues** | 1) helps orient and adjust the hyper-visual<br>2) helps stimulate to action the hypo-visual<br>3) helps organize the interference visual<br>4) creates necessary boundaries for the hypo-tactile<br>5) helps orient the hypo and interference proprioceptive |
| 27. | **Spatial organization according to sensory characteristics** | 1) helps orient and adjust the hyper-visual<br>2) helps organize the interference visual<br>3) helps orient the hypo and interference proprioceptive |
| 28. | **Use of one-way circulation patterns to capitalize on routine** | 1) helps orient and adjust the hyper-visual<br>2) helps organize the interference visual<br>3) helps orient the hypo and interference proprioceptive<br>4) helps create predictability in general across the spectrum, particularly the hyper-auditory |