My Experiences with Visual Thinking Sensory Problems and Communication Difficulties

by Temple Grandin, Ph.D.

Introduction

In this paper, I will describe my experiences with autism. The main areas I will cover are visual thinking, sensory problems, and difficulties with communication.

Sound and Visual Sensitivity

My hearing is like having a sound amplifier set on maximum loudness. My ears are like a microphone that picks up and amplifies sound. I have two choices: 1) turn my ears on and get deluged with sound or 2) shut my ears off. Mother told me that sometimes I acted like I was deaf. Hearing tests indicated that my hearing was normal. I can't modulate incoming auditory stimulation. I discovered that I could shut out painful sounds by engaging in rhythmic stereotypical autistic behavior. Sometimes I "tune out". For example, I will be listening to a favorite song on the car radio and then later realize that I tuned out and missed half of the song. In college, I had to constantly take notes to prevent tuning out.

I am unable to talk on the telephone in a noisy office or airport. Other people can use the telephones in a noisy airport, but I cannot. If I try to screen out the background noise, I also screen out the voice on the telephone. Autistic people with more severe auditory processing problems are unable to hear a conversation in a relatively quiet hotel lobby.

Autistic people must be protected from noises that hurt their ears. Sudden loud noises hurt my ears--like a dentist's drill hitting a nerve (Grandin 1992a). A gifted, autistic man from Portugal wrote: "I jumped out of my skin when animals made noises" (White and White 1987). An autistic child will cover his or her ears because certain sounds hurt. It is like an excessive startle reaction. A sudden noise (even a relatively faint one) will often make my heart race.

I still dislike places with many different noises, such as shopping centers and sports arenas. High-pitched continuous noise, such as bathroom vent fans or hair dryers, are annoying. I can shut down my hearing and withdraw from most noise, but certain frequencies cannot be shut out. It is impossible for an autistic child to concentrate in a classroom if he or she is bombarded with noises that blast through his or her brain like a jet engine. High-pitched, shrill noises are the worst. A low rumble has no affect, but an exploding firecracker hurts my ears. As a child, my governess used to pop a paper bag to punish me. The sudden, loud noise was torture.

The fear of a noise that hurts the ears is often the cause of many bad behaviors and tantrums. Some autistic children will attempt to break the telephone because they are afraid it will ring. Many bad behaviors are triggered due to anticipation of being subjected to a painful noise. The bad behaviors can occur hours before the noise.

Common noises that cause discomfort in many autistic individuals are school bells, fire alarms, score board buzzers in the gym, squealing microphone feedback and chairs scraping on the floor. When I was a child, I feared the ferry boat that took us to our summer vacation home. When the boat's horn blew, I threw myself on the floor and screamed. Autistic children and adults may fear dogs or babies because barking dogs or crying babies may hurt their ears. Dogs and babies are unpredictable, and they can make a hurtful noise without warning.

Children and adults with extreme sound sensitivity may also fear the sound of water flowing or waves (Stehli 1991). Children with less severe auditory sensitivity problems may be attracted to sound and visual stimuli that more severely impaired children tend to avoid. I liked the sound of flowing water and enjoyed pouring water back and forth between orange juice cans; whereas another child may avoid the sound of flowing water. I liked the visual stimulation of watching automatic sliding doors; whereas another child might run and scream when he or she sees an automatic sliding door. A loud vacuum cleaner may cause fear in one autistic child and may be a pleasurable fixation to another child. When I look at moving sliding doors, I get the same pleasurable feeling that used to occur when I engaged in rocking or other stereotypical autistic behaviors. Some autistic individuals can see the flicker of florescent lights. Coleman et al. (1976) found that florescent lights increased repetitive behavior in some autistic children.

Tactile Experiences

During my travels to many autism conferences, several parents have reported to me that holding therapy was beneficial. It is not the "cure" that some of its proponents tout, but it has a beneficial affect on some children. In my

opinion, the benefits of holding therapy could be obtained through less stressful methods. I cringed when I watched the BBC show, "The Visit," and I am glad I did not have to endure forced holding. Fisher (1989) describes a gentler approach to holding that worked with her daughter.
One mother told me that she gently encouraged her child to tolerate more and more holding, and he responded with increased affection and improved eye contact. Powers and Thorworth (1985) found that eye contact and interest in people improved after a gentler behavioral method was used. In one case, a young boy was held in a light hug until crying lessened. As soon as crying was reduced, the boy was released. Gradually, the amount of holding time was increased.
I believe that the beneficial effects of holding in some children are due to desensitization to touch of the autistic child's nervous system. It is a physiological sensory process that has nothing to do with mother bonding or anger. I completely disagree with Welch (1983) that the child has to become severely distressed for holding to be effective. The sensory problems of autism are often overlooked. Many autistic people are over sensitive to both sound and touch. Autistic children have problems modulating sensory input (Ornitz 1985).

Autistic Tactile Problems

I pulled away when people tried to hug me, because being touched sent an overwhelming tidal wave of stimulation through my body. I wanted to feel the comforting feeling of being held, but then when somebody held me, the effect on my nervous system was overwhelming. It was an approach-avoid situation, but sensory over stimulation caused the avoidance, not anger or fear as Richer and Zappella (1989) suggest. An autistic man, interviewed by Cesaroni and Garber, stated that touching was not painful, but it was overwhelming and confusing.
Small itches and scratches that most people ignored were torture. A scratchy petticoat was like sand paper rubbing my skin raw. Hair washing was also awful. When mother scrubbed my hair, my scalp hurt. I also had problems with adapting to new types of clothes. It took several days for me to stop feeling a new type of clothing on my body; whereas a normal person adapts to the change from pants to a dress in five minutes. New underwear causes great discomfort, and I have to wash it before I can wear it. Many people with autism prefer soft cotton against the skin. I also liked long pants, because I disliked the feeling of my legs touching each other.

Sensory Therapy

Therapists have helped many autistic children through gently applying tactile and vestibular stimulation (Ayres 1979; King 1989). One effect of this stimulation is to desensitize the tactile system. This is not a cure, but it has increased speech, affection, and eye contact in some children. It also helps to decrease stereotypical and self-injurious behaviors. The sensory activities are done gently as fun games and are never forced. Strong encouragement and some intrusiveness may be used, but a good therapist knows how far he or she can intrude before the stimulation becomes so overwhelming that the child starts crying. Even intrusive activities are kept fun. During the activities, the therapist will also work on improving speech and establishing eye contact.
Ray et al. (1988) found that a mute child will often start making speech sounds while he or she is swinging in a swing. Swinging stimulates the vestibular system and the defective cerebellum. Spinning in a chair twice a week helps to reduce hyperactivity (Bhatara et al. 1981); and non-contingent vibration will reduce stereotypical behavior (Murphy 1982). Research has also shown that vigorous aerobic exercise reduced maladaptive and stereotypic behavior (Elliot et al. 1994).
Hypersensitivity to touch can be desensitized through firmly but gently stroking a child with different cloth textures (Ayres 1979). The pressure must be firm enough to stimulate deep pressure receptors. Very light touch should be avoided because it increases arousal and excites the nervous system. Vestibular and sensory stimulation also have a beneficial affect on improving affection and social behavior.
Deep pressure stimulation is also calming (Ayres 1979; King 1989) Therapists often roll the children up in mats. Many autistic children will seek deep pressure. Many parents have told me that their children get under the sofa cushions or mattress. A slow, steady application of pressure had a calming affect on me; and a sudden jerky motion tended to cause arousal (Grandin 1992b). Self stimulatory behaviors can be reduced by having an autistic child wear a garment that applies pressure (McClure et al 1991; Zisserman 1992).
Good results can often be obtained with less than an hour of sensory treatment per day. Spending hours and hours each day is not required. If a treatment method is going to be effective with a particular child, it will bring about

improvement with reasonable amounts of effort. The effectiveness of sensory treatment will vary from child to child.

Tactile Research

Both human and animal studies indicate that deep pressure is calming and reduces arousal in the nervous system. Takagi and Kobagas (1956) found that pressure applied to both sides of a person's body decreased metabolic rate, pulse rate, and muscle tone. Gently pinching a rabbit's skin with padded clips creates a deactivated EEG reading, relaxed muscle tone, and drowsiness (Kumazawa 1963). Pressure gently applied to both sides of a pig in a padded V trough will induce sleep and relaxation (Grandin et al. 1989). Rubbing and gently pinching a cat's paw will decrease tonic activity in the dorsal column nuclei and the somatosensory cortex (part of the brain that receives touch sensation) (Melzack et al. 1969).

Squeeze Machine

I craved deep pressure stimulation, but I pulled away and stiffened when my overweight aunt hugged me. In my two books (Grandin and Scariano 1986 and Grandin 1995), I describe a squeeze machine I constructed to satisfy my craving for the feeling of being held. The machine was designed so that I could control the amount and duration of the pressure. It was lined with foam rubber and applied pressure over a large area of my body.

Gradually I was able to tolerate the machine holding me. The over sensitivity of my nervous system was slowly reduced. A stimulus that was once overwhelming and aversive had now become pleasurable. Using the machine enabled me to tolerate another person touching me. A partial explanation for the lack of empathy in autism may be due to an oversensitive nervous system that prevents an autistic child from receiving the comforting tactile stimulation that comes from being hugged. I learned how to pet our cat more gently after I had used the squeeze machine. I had to comfort myself before I could give comfort to the cat. When I handle cattle, I often touch the animals because it helps me to feel gentle towards them. It is important to desensitize an autistic child so that he/she can tolerate comforting touch. I have found that if I use my squeeze machine on a regular basis that I have nicer images in my dreams. Experiencing the comforting feeling of being held makes nasty or mean thoughts go away. Several squeeze machines are now in use at sensory integration clinics in the United States. Therapists have found that some hyperactive and autistic children will immediately use the machine, and others are so oversensitive to touch that they initially avoid the machine and other activities involving touch, such as finger painting or being rubbed with different cloth textures. Over sensitive children are gently encouraged to engage in tactile activities that they initially avoided. An activity that was initially aversive and overwhelming gradually becomes pleasurable. Activities involving touch become pleasurable when the nervous system becomes desensitized. For example, children who cannot tolerate tooth brushing can be desensitized through gently rubbing them around the mouth.

Cognitive Versus Sensory

In this paper I have concentrated on the sensory aspects of autism and have not discussed behavioral and cognitive (thinking) factors. Cognitive and behavioral aspects are important, but I concentrated on the sensory aspects because these are often neglected.

Sensory processing problems may explain some autistic behaviors, and differences in cognitive processes may explain others. Cerebellar and brain stem abnormalities are a probable explanation of many sensory problems, but they would not explain cognitive differences, such as concrete thinking and unusual visual spatial skills. The cognitive differences between autistic and normal children are probably due to other brain abnormalities. Autopsies of nine autistic brains revealed abnormalities in the cerebellum, hippocampus, amygdala, and other parts of the limbic system (Bauman 1991, and Bauman and Kemper 1994). These areas are involved with learning and memory. Brain wave (EEG) studies indicated that autistic children have severe abnormalities in their capacity to shift attention between visual and auditory stimuli (Courchesne et al. 1989). Brain structures that control attention shift are connected to the cerebellar vermis. Abnormalities in attention shifting may be the basis of perseverate (repetitive) behavior and some social deficits. This may possibly explain why treatments that stimulate the cerebellum and certain sensory treatments often improve overall behavior. Further research has shown that the amygdala (emotion center) in the brain is underdeveloped. This may explain some of the social deficits of

autism. Brain scans have revealed that some of the circuits between the frontal cortex and amygdala are not functioning normally (Haznader et al., 1997). This may force a person with autism to use intellect and logic to make social decisions instead of emotion cues.

What is Visual Thinking?

Thinking in language and words is alien to me. I think totally in pictures. It is like playing different tapes in a video cassette recorder in my imagination. I used to think that everybody thought in pictures until I questioned many different people about their thinking processes.

I have conducted an informal little cognitive test on many people. They are asked to access their memory of church steeples or cats. An object that is not in the person's immediate surroundings should be used for this visualization procedure. When I do this, I see in my imagination a series of "videos" of different churches or cats I have seen or known. Many "normal" people will see a visual image of a cat, but it is a sort of generalized generic cat image. They usually don't see a series of vivid cat or church "videos" unless they are an artist, parent of an autistic child, or an engineer. My "cat" concept consists of a series of "videos" of cats I have known. There is no generalized cat. If I keep thinking about cats or churches I can manipulate the "video" images. I can put snow on the church roof and imagine what the church grounds look like during the different seasons.

Some people access their "cat" knowledge as auditory or written language. For me, there is no language based information in my memory. To access spoken information, I replay a "video" of the person talking. There are some brilliant people who have little visual thought. One totally verbal professor told me that facts just come to his mind instantly with no visual image. To retrieve facts, I have to read them off a visualized page of a book or "replay the video" of some previous event. This method of thinking is slower. It takes time to "play" the videotape in my imagination.

Research findings indicate that verbal thought and visual thinking work via different brain systems (Farah 1989; Zeki 1992). Studies of patients with brain damage indicate that one system can be damaged, while another system may be normal. The brain is designed with modular systems. These systems may work either together or separately to perform different tasks. For example, people with certain types of brain damage can recognize objects with straight edges, but they cannot recognize objects with irregular edges. The brain module that recognizes irregular shapes has been damaged (Weiss 1989). In autism, the systems that process visual-spatial problems are intact. There is a possibility that these systems may be expanded to compensate for deficits in language. The nervous system has remarkable plasticity; one part can take over and compensate for deficits in language. The nervous system has remarkable plasticity; one part can take over and compensate for a damaged part (Huttenlocher 1984). A functional MRI study by Ring et al. (1999) indicates that people with autism depend more on the visual parts of the brain on an embedded figures test.

Using Visualization

Visual thinking is a great asset in my career as a livestock equipment designer, and I have become internationally recognized in this field. Drafting elaborate drawings of steel and concrete livestock stockyards and equipment is easy. I can visualize a video of the finished equipment in my imagination. I can run test simulations in my imagination of how the systems would work with different size cattle.

Discussions with other autistic people have revealed visual methods of thinking on tasks that are often considered sequential and nonvisual. A brilliant autistic computer programmer told me that he visualized the entire program tree in his mind and then filled in the program code on each branch. A gifted autistic composer told me that he made "sound pictures". In all these cases, a hazy whole or gestalt is visualized, and the details are added in a non-sequential manner. When I design equipment, I often have a general outline of the system, and then each section of it becomes clear as I add details.

When I solve a scientific problem or review the scientific literature, I do it non-sequentially. The process is like trying to figure out what the picture on a jig saw puzzle is, when only some of the pieces are put together. A piece is put on one corner and then another corner and after about one fourth of the pieces are in place, a person can tell that the puzzle has a picture of a house on it.

As a child and as a young adult, I was good at building things, but it took time to learn how the symbolic lines on a set of engineering drawings related to the "video" of a house or a piece of equipment that was in my imagination.

After I learned to read engineering drawings, I could then instantly translate the symbols on the drawings into a visualization of the finished structure. When I was 28, my drafting ability suddenly improved after I watched a skilled draftsman. I bought a pencil just like his, and then I copied his style, but the drawing I made was a new design. When the drawing was finished I could "play the video" and "test" the equipment to see if it would work. Visual thinking is not a fast method of thinking. It takes time to "play" the "video." I am unable to instantly access my memory. An accountant with autism wrote to me and explained that he had to think slowly at his desk, but he could solve problems that were difficult for other accountants.

Visual thinking is also associated with being intellectually gifted. Albert Einstein was a visual thinker who failed his high school language requirement and relied on visual methods of study (Holton 1971-72). His theory of relativity was based on visual imagery of moving boxcars and riding on light beams. Einstein's family history includes a high incidence of autism, dyslexia, food allergies, high intellectual aptitude, and musical talent, and he himself had many autistic traits - an astute reader can find evidence of them in Einstein and Einstein (1987). Other great scientists such as Leonardo de Vinci, Faraday and Maxwell were visual thinkers (West 1991).

Intellectual giftedness is common in the family histories of many persons with autism. In my own family history, my great grandfather on my father's side was a pioneer who started the largest corporate wheat farm in the world. One sister is dyslexic and is brilliant in the art of decorating houses.

When I think about abstract concepts, such as relationships with people, I use visual images, such as a sliding glass door. Relationships must be approached gently because barging forward too quickly may shatter the door. Thinking about the door was not enough; I had to actually walk through it. When I was in high school and college, I had actual, physical doors that symbolized major changes in my life, such as graduations. At night, I climbed through a trap door on the roof of the dormitory to sit on the roof and think about life after college. The trap door symbolized graduation. The doors were a visual language for expressing ideas that are usually verbalized.

Park and Youderian (1974) also report use of visual symbols, such as doors, to describe abstract concepts. Visualization enabled me to understand the Lord's Prayer. "The power and the glory" were high-tension electric towers and a blazing rainbow sun. I visualize the word trespass as a "No Trespassing" sign on the neighbor's tree. I no longer use sliding doors to understand personal relationships, but I still have to relate a particular relationship with something I have read or experienced. For example, a fight between my neighbors was like the United States and Europe fighting over customs duties. All my memories are visual images of specific events. New thoughts and equipment designs are combinations and rearrangements of things I have previously experienced. I have a need to see and operate all types of livestock equipment because that programs the "visual computer."

Park (1967) also explained that her daughter learned nouns first. Nouns are easy because they can be associated with pictures in one's mind. Inappropriate words are often used. For example, the name Dick was used to refer to painting. This happened because Park's daughter saw a picture of Dick painting furniture in a book. Park (1967) also describes why her daughter had problems with pronoun reversal and won't use the word I. She thinks her name is you because that's what people call her. Charlie Hart summed up autistic thinking with this statement about his autistic son Ted: "Ted's thought precesses aren't logical, they are associational" (Hart 1989). The autistic person's visual thinking methods may explain some of the "Theory of Mind" problems that Frith (1989) outlines. Visual and associational thinking would explain Frith's observation that a child may say "French toast" when he or she is happy.

I still have difficulty with long strings of verbal information. If verbal directions contain more than three steps, I have to write them down. Many autistics have problems with remembering the sequence of a set of instructions. Children with autism perform best with written instructions that they can refer to, compared to verbal instructions or a demonstration of a task, which require remembering a sequence of steps (Boucher and Lewis 1989).

Algebra is almost impossible, because I can't make a visual image, and I mix up steps in the sequence of doing a problem. I have many dyslexic traits, such as reversing numbers and mixing up similar sounding words such as over and other. Learning statistics was extremely difficult, because I am unable to hold one piece of information in my mind while I do the next step. I had to work with a tutor and write down the directions for doing each test. Every time I do a statistical test, I have to use notes. It is easy to understand the principles of statistics, because I can visualize the normal or skewed population distributions. The problem is, I cannot remember the sequence for doing the calculations.

Donna Williams (1992), an autistic woman from Australia, describes similar difficulties. She was unable to learn math until she watched the teacher write out each step. Like me, she had to see every step written on paper. If the

smallest step is left out, the autistic mind will be stumped. The visual image of all the written steps is essential. Donna also became frustrated because her calculator did not have an "of" button for finding percents. Words that have no concrete visual meaning such as "put" or "on" need to be seen in written form in order to be heard and remembered (Park 1967). Written language is easier to understand than verbal language. Word processors should be introduced early to encourage writing. Typing is often easier than hand writing. Many autistics have motor control problems that result in messy illegible writing. Even highly verbal people with autism can often express themselves better using the written or typed word. When I want to describe how I really feel about something, I can express myself better in writing.

Communication

I screamed because it was the only way I could communicate. When adults spoke directly to me, I could understand everything they said. When adults talked among themselves, it sounded like gibberish. I had the words I wanted to say in my mind, but I just could not get them out; it was like a big stutter. When my mother wanted me to do something, I often screamed. If something bothered me, I screamed. This was the only way I could express my displeasure. If I did not want to wear a hat, the only way I could communicate my desire not to wear the hat was to throw it on the floor and scream. Being unable to talk was utter frustration. I screamed every time my teacher pointed the pointer towards me. I was afraid because I had been taught at home never to point a sharp object at a person. I feared that the pointer would poke out my eye.

The speech therapist had to put me in a slight stress state so I could get the words out. She would gently hold me by the chin and make me look at her and then ask me to make certain sounds. She knew just how much to intrude. If she pushed too hard, I would have a tantrum; if she did not push enough, there was no progress. During recent visits to autism programs, I have observed this technique being used in many different types of programs. When I started to speak, my words were stressed with an emphasis on vowel sounds. For example, "bah" for ball. My speech therapist stretched out the hard consonant sounds to help my brain to perceive them. She would hold up a cup and say “ccc u ppp.” Vowels are easier to hear than consonants. My speech and language problems were similar to the loss of speech that occurs in children who have had brain surgery to remove tumors in the cerebellum and cerebellar vermis (Rekate et al. 1985). The children lost speech and then regained their ability to speak a few stressed words at a time. The ability to understand speech remained normal. Courchesne et al. (1988) and Murakami et al. (1989) found that in moderate to high-functioning autistics, a high percentage had either an undersized cerebellum or abnormalities of the cerebellar vermis. In my own case, MRI brain scans revealed that my cerebellar hemispheres are smaller than normal.

Educational Strategies and Subtypes

A teaching and therapy program that worked well for me may be painful and confusing to some nonverbal lower functioning, regressive/epileptic people with autism. My speech therapist forced me to look at her. I needed to be jerked out of my autistic world and kept engaged. Some children with more severe sensory problems may withdraw further because the intrusion completely overloads their immature nervous system. They will often respond best to gentler teaching methods such as whispering softly to the child in a room free of florescent lights and visual distractions. Donna Williams (1994) explained that forced eye contact caused her brain to shut down. She states when people spoke to her, "their words become a mumble jumble, their voices a pattern of sounds" (Painter 1992). She can use only one sensory channel at a time. If Donna is listening to somebody talk, she is unable to perceive a cat jumping up on her lap. If she attends to the cat, then speech perception is blocked. She realized a black thing was on her lap, but she did not recognize it as a cat until she stopped listening to her friend talk.

She explained that if she listens to the intonation of speech, she can't hear the words. Only one aspect of incoming input can be attended to at a time. If she is distracted by the visual input of somebody looking in her face, she can't hear them. Other people with autism have explained that they had a difficult time determining that speech was used for communication. Kins, a man with autism, further explained that if somebody looked him in the eye, "My mind went blank and thoughts stop; it was like a twilight state." Cesaroni and Garber (1991) also describe confusing and mixing of sensory channels. Jim, a man with autism, explained, "Sometimes the channels get confused, as when sounds came through as color." He also said that touching the lower part of his face caused a sound-like sensation. Donna told me that she sometimes has difficulty determining where her body boundary is. Cesaroni and Garber (1991) also noted problems with locating a tactile stimulus. The tendency of some autistic people to constantly touch themselves and objects around them may be an attempt to stabilize body and environmental

boundaries. Therese Joliffe, an autistic woman, explained that it was easier to learn by touch because touch was her most accurate sense (Joliffe et al. 1992). Donna told me that sensory integration treatment, consisting of rubbing her skin with brushes, has helped. Even though she disliked the tactile input from the brushes, she reported that it helped her different sensory systems to work together and become more integrated. Her sensory processing also becomes more normal when she is relaxed and is focusing on only one sensory channel. Donna may be half way along the continuum between the Kanner/Asperger Type and the Regressive Epileptic Type.

Conclusions

Teachers, therapists and other professionals who work with autistic people need to recognize and treat sensory processing problems in autism. Treatment programs that are appropriate and beneficial for one type of autism may be painful for other types. At ages two to four, many autistic children will probably respond well to gently intrusive programs where the child is required to maintain eye contact with the teacher. Lovaas (1987) has documented that roughly half of young children will improve sufficiently so they can be enrolled in a normal first grade at age six or seven. It is likely that the children who did not improve in the Lovaas program were experiencing sensory overload. They may respond better to a gentler approach using only one sensory channel at a time. As children get older they tend to separate into two groups. Children like me who can be "jerked" out of the autistic world and asked to pay attention, and individuals like Donna Williams and Therese Joliffe who require a gentler approach. The prognosis of both types of children will be improved if they receive a minimum of 20 hours a week of good educational programming between the ages of two and five. Both types of young autistic children MUST be prevented from shutting out the world. They have to be kept engaged so that their brains can develop more normally. For one type of child the teacher can "jerk open the front door;" and for the other type, the teacher must "sneak quietly through the back door."

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