

*Review*

# How does visual thinking work in the mind of a person with autism? A personal account

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My mind is similar to an Internet search engine that searches for photographs. I use language to narrate the photo-realistic pictures that pop up in my imagination. When I design equipment for the cattle industry, I can test run it in my imagination similar to a virtual reality computer program. All my thinking is associative and not linear. To form concepts, I sort pictures into categories similar to computer files. To form the concept of orange, I see many different orange objects, such as oranges, pumpkins, orange juice and marmalade. I have observed that there are three different specialized autistic/Asperger cognitive types. They are: (i) visual thinkers such as I who are often poor at algebra, (ii) pattern thinkers such as Daniel Tammet who excel in math and music but may have problems with reading or writing composition, and (iii) verbal specialists who are good at talking and writing but they lack visual skills.

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## 1. INTRODUCTION

My mind works similar to an Internet search engine, set to locate photos. All my thoughts are in photo-realistic pictures, which flash up on the ‘computer monitor’ in my imagination. Words just narrate the picture. When I design livestock facilities, I can test run the equipment in my imagination similar to a virtual reality computer program. I did not know that this was a special skill until I started interviewing other people about how they think. I was surprised to discover that the other non-autistic equipment designers could not do full motion test runs of equipment in their minds.

My mind is associative and does not think in a linear manner. If you say the word ‘butterfly’, the first picture I see is butterflies in my childhood backyard. The next image is metal decorative butterflies that people decorate the outside of their houses with and the third image is some butterflies I painted on a piece of plywood when I was in graduate school. Then my mind gets off the subject and I see a butterfly cut of chicken that was served at a fancy restaurant approximately 3 days ago. The memories that come up first tend to be either early childhood or something that happened within the last week. A teacher working with a child with autism may not understand the connection when the child suddenly switches from talking about butterflies to talking about chicken. If the teacher thinks about it visually, a butterfly cut of chicken looks like a butterfly.

## 2. PUTTING LITTLE PIECES TOGETHER

When I design equipment, I take bits and pieces of other equipment I have seen in the past and combine

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them to create a new system. All my thinking is bottom-up instead of top-down. I find lots of little details and put them together to form concepts and theories.

During the last 5 years, I successfully used this method to fix some of my health problems. Most people have to have a theory first, and then they try to make the data conform to it. My mind works the opposite way. I put lots of little pieces of data together to form a new theory. I read lots of journal papers and I take little pieces of information and put them together as if completing a jigsaw puzzle. Imagine if you had a thousand-piece jigsaw puzzle in a paper bag and you had no idea what the picture on the box is. When you start to put the puzzle together, you will be able to see what the picture is when it is approximately one-third or one-quarter of the way completed. When I solve the problem, it is not top-down and theory driven. Instead, I look at how all the little pieces fit together to form a bigger picture.

When I was in college, I called this *finding the basic principle*. On everything in life, I was overwhelmed with a mass of details and I realized that I had to group them together and try to figure out unifying principles for masses of data.

## 3. FINDING A UNIFYING PRINCIPLE IN SCIENTIFIC LITERATURE

I have recently started to lose my hearing. The ear specialist said that there was nothing I could do. I did not accept this; so I spent two weeks at the computer reading journal papers on sudden sensorial hearing loss, Meniere’s disease and other disorders. I had to read hundreds of abstracts and journal papers just to get the background information so that I could find the answer that would save my hearing. I was looking for

a unifying principle that would explain all the research results. One study reported that steroids such as Prednisone could save my hearing and another study reported that steroids do not work. How did I sort the data out? The first clue was that many studies were published in arthritis journals instead of ear and nose journals. The reason for this is that arthritis doctors really understand autoimmune disorders where the immune system attacks a person's body. In my mind, I pictured wrecked, deformed arthritic joints. For a treatment to be successful, the drug has to be given *before* the immune system has destroyed the joints. I then had a flash of visual thinking insight. I imagined that the immune system attacking my inner ear was such as a house on fire. This is what I call a *visual symbol picture*. If the fire is put out when it is confined to a waste basket, the house can be saved. If the whole house starts burning, it will be destroyed. The explanation for all the conflicting studies in the medical journals was really simple. Steroid drugs such as Prednisone put out the fire of autoimmune inflammation, but they do not repair the damage. Treatment has to be started before the ear is wrecked. The explanation for all the conflicting scientific studies was a simple basic principle. I had to get a prescription for Prednisone before the autoimmune inflammation destroyed my inner ear. I looked up a second ear specialist in the phone book and he immediately gave me the prescription that saved my hearing.

#### 4. FILLING UP THE INTERNET IN MY MIND

The method of bottom-up thinking really works well for me in problem solving where a basic principle has to be determined from masses of conflicting data. One disadvantage of my kind of thinking is that huge amounts of data are required to find the answers. Since my mind works similar to an Internet search engine, my ability to solve problems got better and better as I had more and more experiences and read more and more books and journal papers. This provided lots of images in my memory for the search engine in my mind to search. Many people have told me that my talks have improved between the ages of 40 and 60. My ability to think in a less rigid way keeps getting better as I fill up the Internet in my mind with more and more information. I greatly improved socially in my 40s and 50s compared with my 20s. This was due to having more experiences in my memory that provided guidance on how to behave.

#### 5. DOOR SYMBOLS

When I was in high school at age 16, many teachers did not understand why I kept talking about going through little doors and thinking in visual symbols. Since my mind stores information as photo-realistic pictures, I do not have true abstract thinking. To visualize the concept of my future after high school, I had to use door symbols. In fact, the first door symbols were real doors I could practise walking through. Today I no longer think in door symbols because I have a huge database in the Internet inside my head. Instead of visualizing doors, I visualize either real past experiences or events I have read about.

#### 6. CATEGORIES ARE THE BEGINNING OF CONCEPT FORMATION

To form a concept from the many specific photo-realistic pictures I have stored in my memory, I sort them into categories. Categorization of my specific visual memories was the beginning of concept formation (Grandin 2000, 2002). When I was a child, I categorized dogs from cats by sorting the animals by size. All the dogs in our neighbourhood were large until our neighbours got a Dachshund. I remember looking at the small dog and trying to figure out why she was not a cat. I had to find a visual feature that she shared with big dogs. I had to create a new category in my mind to differentiate. All dogs, no matter how big or small, have the same nose shape. My concept is sensory based, not word based. Other ways of sensory-based categorization would be sound (barking or meowing) or smell.

Researchers have found that people with autism often have difficulty in forming new categories (Minschew *et al.* 2002). When I was a child, we played lots of games such as Twenty Questions that forced me to get good at thinking in categories. Category formation is a fundamental property of the nervous system. Brains are wired to put visual information into categories (Freedman *et al.* 2001). The hippocampus also has the ability to determine whether or not similar photos of objects are the same or different (Bakker *et al.* 2008). Observations of stroke patients have shown that brain damage can cause them to lose their ability to categorize objects such as tools, but they can still categorize vegetables and animals (e.g. Mummery *et al.* 1998).

In my case even abstract questions are answered by putting photo-realistic pictures into categories. One time I was asked 'Is capitalism a good system?' To answer this question, I put pictures from countries that had different types of governmental systems into the following categories: (i) capitalistic, (ii) capitalistic/socialistic, (iii) socialistic, (iv) benevolent dictatorship, (v) brutal dictatorship, and (vi) war and chaos. These pictures were taken from my memory and they are from experiences travelling or the news media. My answer was that I absolutely do not want to live in a brutal dictatorship, or war and chaos. Pictures helped me make a choice because in the last two choices I see news photos and TV images of killing and destruction.

My ability to provide a well thought-out answer has greatly improved with age because I have travelled more, and have more pictures both from actual experiences and from reading. They can be sorted into the different categories. When I read, I convert text to images as if watching a movie. The images are then stored in my memory. In college, I photocopied images of my class notes into my brain. When I was a teenager, answering the question about capitalism in an intelligent manner would have been impossible. I simply did not have enough experiences or enough information in my memory to answer it.

#### 7. HOW I DEVELOPED FASTER CATEGORY THINKING

In college, the process of sorting out the basic principles from masses of data was much slower and

laborious compared with my abilities today at 60. I figured out my ear problem in two weeks. When I was in my 20s, it took me 10 times longer to develop a theory from 100 journal papers.

As an undergraduate, I did an honour's thesis on the subject of sensory interaction. Here the question was how a stimulus to one sense, such as hearing, affects the sensitivity of other senses. I had over 100 journal papers and I numbered each paper. On small pieces of paper, I typed the major findings of each study. I then pinned hundreds of little slips of paper on a bulletin board. I called it my logic board. Since my thinking is totally non-sequential, I had to develop a way so I could see a display of all the information at the same time on the bulletin board. To discover the categories and concepts, I started pinning the slips of paper into different categories. It was very time-consuming. As I gained more experience with sifting through scientific research, I no longer needed the bulletin board. I became better and better at finding unexpected clues, such as many deafness treatment papers being in arthritis journals. From my previous scientific knowledge, I made the association of rheumatoid arthritis to autoimmune, and therefore saw that ear damage would work the same way as joint damage.

When I was young, my thinking process was extremely slow because I was less skilled at finding the *basic principle* from the masses of data. But skills in people on the autism spectrum still develop when they are adults. The more research I did analysing the results of scientific studies, the better I got at it. I always read the methods section of a paper carefully so I can visualize how the experiment was done. Differences in methods often explain conflicting results of scientific studies.

## 8. DIFFERENT WAYS OF THINKING

For many years I thought everybody else thought in pictures the same way as I do. When I wrote *Thinking in pictures*, I started interviewing people about how they think. I was shocked to learn that most people processed information differently to how I did. Most people are able to visualize their own car or visualize walking through their own house. They can do it because they are very familiar with it. I discovered the differences in thinking when I asked other people about objects they were less familiar with. I asked them about an object that everybody sees really often, but it was not visible when I asked the question. I always ask the question in the exact way so I do not bias the answer. 'Access your memory of church steeples. How do they come into your mind?' I was shocked to discover that many people saw a vague generalized steeple and sometimes it was a stick figure. They saw a generalized steeple where I saw only a whole lot of photo-realistic pictures of specific ones that I could identify. Research by Nancy Minshew and her colleagues has shown that in people with autism, word-based tasks are processed in the visual parts of the brain. Functional magnetic resonance imaging scanning indicated that sentences with both high and low visual imageries were processed in the visual parts of the brain in the autistic subjects and that low visual

imagery sentences were processed in the language parts of the brain in normal subjects (Kana *et al.* 2006). The sentences with high visual imagery were about animals and plants. One of the low visual imagery sentences was about arithmetic. When I did the experiment, I instantly saw my third-grade teacher writing on the blackboard and explaining borrowing in subtraction.

## 9. AUTISTIC THINKING IS SPECIALIZED

When I wrote *Thinking in pictures* (Grandin 1995) I thought everybody on the autism/Asperger spectrum was a *visual* thinker. People with autism and Asperger's are *specialist* thinkers. They are good at one thing and bad at other things. From both books and interviews, I have concluded that there are three principal types of specialist thinking.

- (i) *Photo-realistic visual thinkers*—such as I. All my thoughts are in photo-realistic pictures (Grandin & Johnson 2005). My area of weakness is in algebra because there is no way to visualize it. Visual thinkers can do geometry and trigonometry, but not algebra. For my work, visual thinking is very important. I can see everything in my head and then draw it on paper. Figures 1 and 2 show two of my drawings, done by hand, of livestock handling facilities. They date from the mid-1980s when I did much of my best work.
- (ii) *Pattern thinking—music and math mind*. This is a more abstract form of visual thinking. Thoughts are in patterns instead of photo-realistic pictures. Pattern thinkers see patterns and relationships between numbers. Some of the best descriptions are in Daniel Tammet's book *Born on a blue day* (Tammet 2006) and in Jerry Newport's book *Mozart and the whale* (Newport *et al.* 2007). The weak area in pattern thinkers is usually reading and writing composition.
- (iii) *Word—fact thinkers*. These individuals have a huge memory for verbal facts on all kinds of things such as film stars and sporting events. They are often poor at drawing and other visual thinking skills.

## 10. DIFFERENT KINDS OF BRAINS

Recent research on the white matter in the brain may provide an explanation for the uneven profile of abilities that is found in many individuals with autism. There are defects in the white matter interconnections between different localized brain regions. Courchesne *et al.* (2004) called these connections the 'computer cables' that wire different parts of the brain together. The frontal cortex gets less connections than other parts of the brain, but some local areas in the brain may get extra connections (Minshew & Williams 2007). Casanova and colleagues (2006, 2007; Casanova & Trippe 2009) found that the brain of both famous neuroscientists and people on the autism spectrum have more circuits (mini-columns) per square centimetre of brain. They suggest that this may explain savant-like skills. The disadvantage of this type of brain construction is that these small circuits have fewer long-distance connections between distant brain regions that facilitate complex social behaviours.

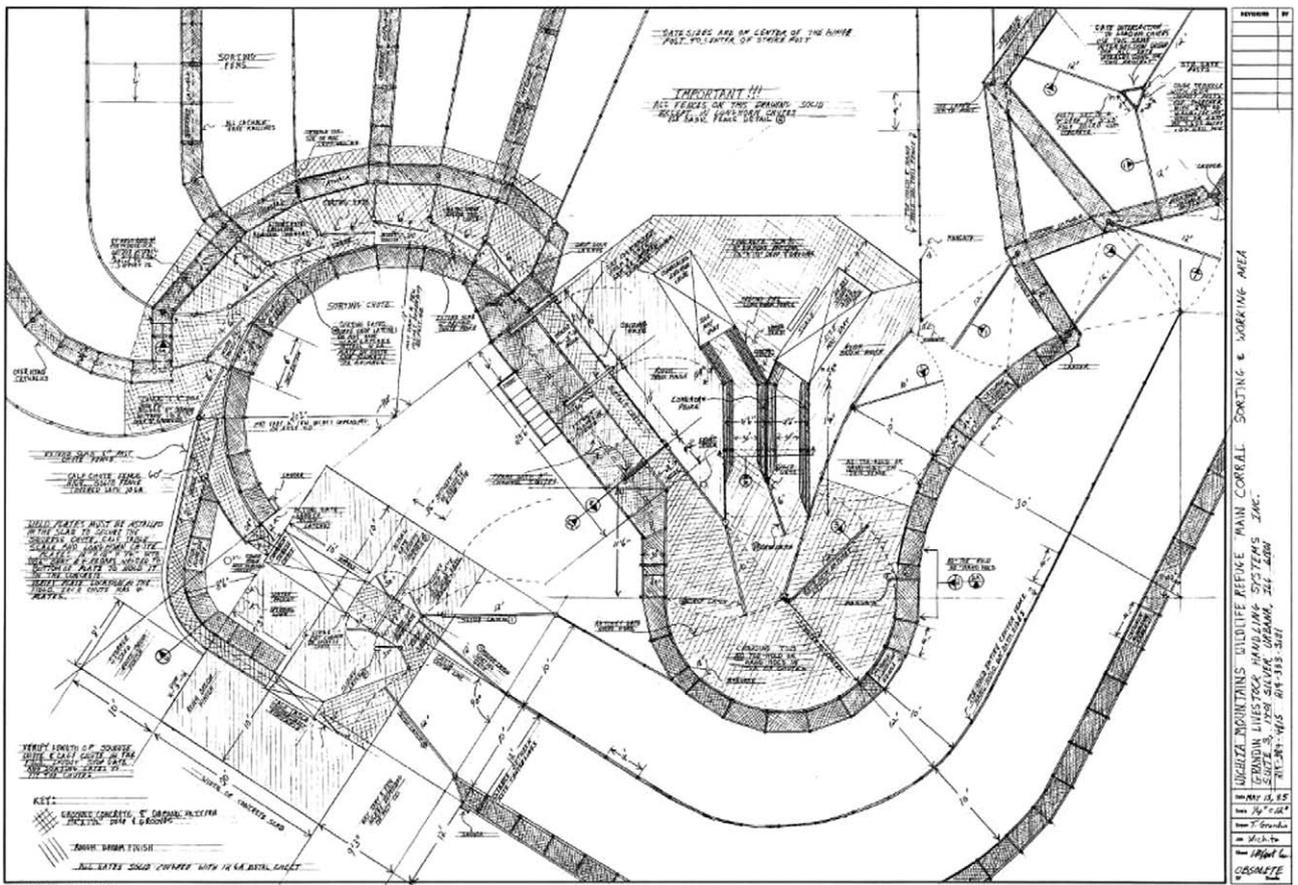


Figure 1. Drawings of livestock handling facilities by Temple Grandin dated 13 May 1985.

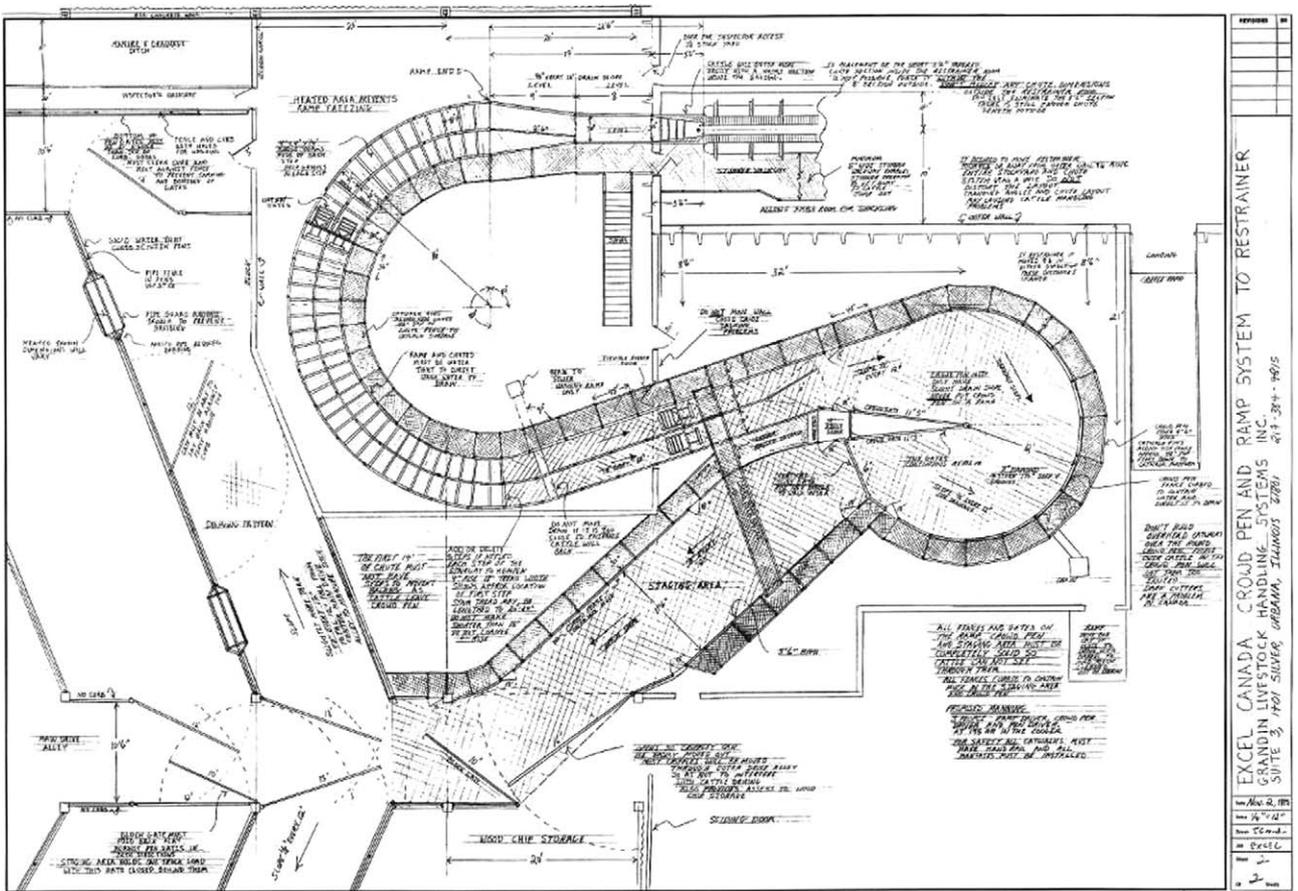


Figure 2. Drawings of livestock handling facilities by Temple Grandin dated 02 November 1987.

There is a wide range of brains that should be considered part of normal variation. A brain can be built with larger fast circuits that facilitate social communication or smaller, slower circuits that improve cognition in a specialized area.

In any information processing system, there are always trade-offs. Brains with high-speed connections to many distant areas will be fast and details will be missed. Research shows that normal brains fail to process details that the autistic person perceives (see Happé & Frith 2009; Happé & Vital 2009). My model for visualizing the different types of brains is a large corporate office building. The president (frontal cortex) is located at the top and he has telephone and computer connections (white matter) to offices throughout the building. I hypothesize that in a highly social brain, the frontal cortex has high-speed connections that go mainly to the department heads in the building. The network is fast and details are omitted. In the autistic/Asperger brain, the frontal cortex is poorly connected, but the visual and auditory parts of the brain (technical nerd departments) have lots of extra local connections providing better processing of detailed information.

## 11. AUTISTIC INTELLIGENCE

Michelle Dawson, a woman with autism, has teamed up with Laurent Mottron, a researcher in Canada, to show that autistic intelligence goes beyond just rote memorization. Instead of using just the Wechsler IQ tests, they tested both normal and autistic children with Raven's Progressive Matrices (Dawson *et al.* 2007). In this test, the person is shown complicated patterns and he/she has to choose the pattern that will complete a series of patterns. Dawson and colleagues found that the IQ scores for the autistic children were 30–70 percentile points higher on the Raven's compared with the Wechsler Intelligence Scale for Children (WISC), while normal children have similar IQ scores when given the Raven's and the WISC. Scheuffgen *et al.* (2000) found that children with autism can show fast information processing despite poor measured IQ. These results show that autistic intelligence is truly different.

In 2006, Nancy Minshew and her colleagues performed a method called diffusion tensor imaging on me. They found a huge white fibre tract that runs from deep in my visual cortex up to my frontal cortex. It is located in the brain slice made at the level of my eyes. It is almost twice as large as my sex- and age-matched controls. I used to joke about having a big high-speed Internet line deep in my visual cortex. It has turned out that I really do have one. This may explain my ability to read massive amounts of detailed literature and sort out the details. In my case, abstract thought based on language has been replaced with high-speed handling of hundreds of 'graphics' files. Studies of patients with frontotemporal dementia show that language-based thinking can cover up detailed visual thinking and music. As the disease destroys the frontal lobe and the language parts of the brain, art and music talent can emerge in people who had no previous interest in art or music (Miller *et al.* 1998, 2000; see also Snyder 2009).

## 12. HARNESSING AUTISTIC CREATIVITY AND ASPERGER'S SYNDROME

I am concerned that people with mild Asperger's syndrome may be held back by the diagnosis because people may perceive them as not capable. Simon Baron-Cohen asks 'is Asperger's syndrome a disability?' (Baron-Cohen 2000; see also Baron-Cohen *et al.* 2009). Many famous musicians, scientists, artists and politicians would probably be diagnosed with Asperger's syndrome if they were children today (Ledgin 2002; Fitzgerald & O'Brien 2007). What would happen to them in today's system? In the USA, the lucky ones get apprenticed into the Silicon Valley technical world by their parents. Many parents in technical fields teach their children their jobs at a young age. The unlucky ones do not have somebody to help them develop their skills. In countries such as China or India, a person with mild Asperger's syndrome would go to engineering or computer science school. I have discussed this with parents from India or East Asia and they stress working with the child from a young age in career-relevant skills. We need to be working to develop the unique abilities of these individuals. I am worried about them getting 'stuck in a rut' and their creative skills will not be used.

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