Evan, a fifth grade student, was extremely agitated. “They don’t belong there. Make them go away,” he said pointing toward the three construction trailers taking up half of the playground. His teacher calmly explained, “The construction men put the trailer there this summer. They needed them to put their work things in. The men will come to pick them up as soon as they have a chance.” “They don’t belong there. Make them go away,” Evan repeated with an increasingly high pitch. His teacher once again tried to reason with him, explaining the purpose of the trailers and why they weren’t moved yet. Evan threw himself onto the floor and began screaming, “They don’t belong there.” The teaching assistant then removed him from the room.

Evan’s response might at first seem out of proportion with the problem of the construction trailers being left on the playground. But his perception of the problem was very different than that of his teacher because Evan has autism. This chapter is about the cognitive and brain basis of autism or what is different about the brain in individuals with autism that leads to differences in how they think and perceive things. Understanding how people with autism think is the foundation for effective and appropriate intervention. Intervention based on an understanding of the neurocognitive aspects will help individuals with autism maximize their function and their happiness. Studies of the brains of individuals with autism provide evidence of differences in how the brain is organized, in how it functions, and even in its size. Thinking differently is not a choice in autism, but a consequence of very real differences in the brain.

Autism as a Disorder of Information Processing

Previously considered a psychological or behavioral disorder, autism was accepted to be of neurologic origin in the 1960’s (Minshew, Sweeney, Bauman, & Webb, 2005). The search was then on for what it was about cognition and the brain that caused the behavior that is called autism. By cause, what was meant was the deficit or alteration in thinking and in the brain that led to the abnormal behavior. Two approaches to understanding autism were subsequently pursued.

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The first approach focused on individual deficits based on the hypothesis that a single deficit causes a cascade that results in the entire constellation of deficits in autism. The specific deficit hypothesized as “the core deficit” in autism has varied over the decades and from investigator to investigator. Eventually it became apparent from accumulated research that there was evidence in autism of many such deficits, and the focus shifted to emphasizing temporal primacy of specific deficits. By this, theorists emphasized that one of the deficits preceded all others with an onset in infancy. Such hypotheses are difficult to test and no evidence has yet substantiated the pre-existence of a single deficit in the absence of other deficits. The most popular of such theories now propose a primary impairment in the ability to shift attention (Courchesne et al., 1994), in representational capacity (Meltzoff & Decety, 2003), or in social motivation or orienting to social stimuli (Dawson, Webb, & McPartland, 2005; Schultz, 2005).

An alternative approach is to investigate the evidence of all simultaneously occurring impairments and intact abilities. The purpose of this investigation is to identify a common denominator of impairments and abilities that illuminates fundamental principles about cognition and the brain in autism. This is the traditional approach of neurologists, recognizing that brain abnormalities rarely result in a single impairment but rather a constellation, the pattern of which reflects the nature of the biologic disturbance. For example, the constellation of deficits resulting from acquired insults to the brain may reflect the distribution of a blood vessel, the coup-counter-coup pattern of a traumatic injury, or the vulnerability profile of a metabolic insult. The constellation of deficits resulting from a developmental disturbance may reflect the pattern of a first trimester abnormality in the formation of the brain, a second trimester disturbance in neuronal proliferation or migration, or a third trimester disturbance in neuronal organization. A developmental disturbance might also reflect the impact of fetal exposure to a virus or toxin.

Based on this perspective, we approached the investigation of the cognitive basis of autism by simultaneously assessing all the common domains of neuropsychologic functioning in samples of high functioning children, adolescents and adults with autism (those with Full Scale and Verbal IQ scores of 70 and above). High functioning individuals were selected because they had all the features specific to autism without potential non-specific features associated with mental retardation; they could be IQ matched to a normal control group; and, they could cooperate for a comprehensive battery of tests. The principle of subgroup studies is that the subgroup is a proxy for the entire group of people with autism even though they are not representative of the entire group. That is, even though they are not mentally retarded with autism, they have the same disorder as individuals with autism who are mentally retarded. Therefore, principles or characteristics identified in this subgroup can be considered to be true of autism as a whole. Extrapolation of these characteristics or principles to more impaired individuals with autism requires consideration of their expression in a more severe form. However, the specific

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1 An injury in which the brain is damaged on impact with the inside of the skull at the site of impact and then suffers additional damage when the brain moves back and forth hitting the inside of the bony skull.
qualities of the disorder would remain the same no matter what the functioning level of the affected individual.

To date, three studies, two involving adult samples and one involving children, have been completed. The first study included 33 individually matched pairs of adolescents and adults with autism compared to individually matched normal controls, all of whom had Full Scale and Verbal IQ scores of 80 and above (Minshew, Goldstein, & Siegel, 1997). The diagnosis of autism was established with the Autism Diagnostic Interview—Revised (ADI-R; Le Couteur et al., 1989; Lord, Rutter, & Le Couteur, 1994), a two hour structured interview developed for research to standardize the early developmental history and current functioning in the areas of social, communication, and restricted interests and repetitive behavior relevant to the diagnosis of autism, and the one-hour Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1989; Lord et al., 2000), a direct observation of the individual composed of a number of tasks designed to elicit social, communication and play abilities relevant to the diagnosis of autism. All items were scored using set ratings and the items were then scored according to DSM-IV criteria for autism. The diagnosis of autism made in this way was confirmed by expert clinical opinion. Individuals with autism with fragile-x syndrome, tuberous sclerosis or other identifiable cause for autism were excluded from participation in the study.

This first study with adults with autism (Minshew et al., 1997) revealed a unique profile of impaired and intact abilities displayed in Table 1, below.

Table 1: Intact or Enhanced Abilities & Deficits in Adults with High Functioning Autism

<table>
<thead>
<tr>
<th>Intact or Enhanced</th>
<th>Cognitive Weaknesses</th>
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<tr>
<td>Attention</td>
<td>Complex Motor</td>
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<tr>
<td>Sensory Perception</td>
<td>Complex Memory</td>
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<tr>
<td>Elementary Motor</td>
<td>Complex Language</td>
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<tr>
<td>Simple Memory</td>
<td>Concept-formation</td>
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<tr>
<td>Formal Language</td>
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<tr>
<td>Rule-learning</td>
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<tr>
<td>Visuospatial processing</td>
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</table>

The first principle apparent from this profile is that the acquisition of information in autism was intact. That is, the capacity to attend to (attention), perceive (elementary sensory perception), and remember (basic memory abilities) information was not impaired relative to the controls. In addition, basic or elementary skills in the other domains tested were also intact. Formal language abilities (spelling, reading words and non-words, speaking words) were superior to the age and IQ matched controls. The capacity for learning the attributes or characteristics of objects and rules was intact. On the other hand, relative impairments were present in higher cortical sensory perception (what is the object in your hand; are you being touched at two analogous spots

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ii In Europe this would be ICD-10 criteria.
on opposite sides of your body; what is the number being drawn on your fingertip), skilled motor movements (handwriting, tying shoes, skipping), memory for complex material (a large amount of the same type of material like word lists or material that is inherently complex like scenes or stories), higher order language (idioms, metaphors, inferences, paragraph comprehension), flexibility (shifting strategies when one does not work in the circumstance), and concept formation (problem solving when there are not set rules; associated skills are insight and judgment). The over-riding principles of this pattern, other than the integrity of information acquisition, were not immediately apparent. It was not a pattern that had been seen before in other diseases. The principles to emerge were the following. First, the acquisition of information was intact in autism. However, information processing capacity was reduced or constrained. This constraint disproportionately impacted higher order information processing or the capacity to process information or material when the demands of the task or situation are high. This processing constraint occurred at a lower level than would be expected based on the individual’s age and IQ.

The predominance of symptoms across domains appeared to reflect the complexity of the information processing demands. This provided an explanation for the preponderance of symptoms in the social, communication and reasoning domains. However, the presence of impairments not part of the diagnostic triad and even not predicted (e.g. in memory and in the motor) strongly suggested that the neurobiology or brain basis of this disorder involved a mechanism that was general to the development of brain architecture and, therefore, was not confined to the three neural systems underlying the diagnostic triad.

The second study involved 56 children with high functioning autism and 56 typically developing children between the ages of eight and 15 years with Full Scale and Verbal IQ scores above 80 and between 80 and 120 (Williams, Goldstein, & Minshew, in press). These findings replicated the major principles of the initial adult study with minor differences. One particular interesting difference was the more prominent sensory symptoms in the children with autism than in the adults, suggesting some amelioration or lessening in sensory symptoms over time. Another difference was that the impairments in concept formation appeared more prominent in the adult study. One possible explanation for this finding is that neither the children with autism nor the typically developing controls may have reached the level of development that allowed the manifestation of the reasoning impairments in autism. It is clear from our studies and the literature that abstraction abilities dependent on the frontal lobe mature in the second decade of life in typically developing children. However, adolescents with autism do not acquire these skills and then between group differences emerge on more and more tests in the concept formation domain (Minshew, Meyer, & Goldstein, 2002).

The third study involving a second sample of adults replicated the first set of results (Minshew & Goldstein, unpublished data). Therefore, there is consistent evidence across a large age range of constraints on information processing that disproportionately impact higher order or integrative
processing. These constraints transcend domains to involve sensorimotor and memory abilities not previously appreciated to be integral elements of this syndrome. The diagnostic triad concept of autism therefore needs to be expanded and the concept that this is merely or predominantly a disorder of social function or interactions needs to be set aside. Indeed the difficulties with restricted and repetitive behavior, common sense, insight and judgment are as impairing as the social impairment. These have been referred to as the non-social or cognitive aspects of autism.

Utility of the Complex Information Processing Concept

One of the first concerns of a researcher upon completing a study that suggests a new principle is whether there is independent validation – a different method from a different investigator – that provides confirmation that the conclusion is correct. If autism is a disorder characterized by a reduced capacity for information processing, then one would expect to find a decline in performance during a dual task (one that requires simultaneous processing of two types of incoming information). A study of dual task processing with individuals with autism was found in the literature (Garcia-Villamisar & Della Sala, 2002). This study involved 16 individuals with autism with average IQ scores compared to 16 normal controls. Each group performed two tasks individually and then simultaneously. The tasks were digit recall (similar to remembering a phone number) and motor tracking (like moving a pen to keep up with a moving dot). These are not demanding tasks. When each task was performed individually, the autism group performed similarly to the control group. When the control group performed both tasks simultaneously, their performance rate on the individual tasks was unchanged from when they performed the tasks individually. However, when the autism group performed the tasks simultaneously, their performance declined about 40%. This is a dramatic example of the constraints on information processing in individuals with autism. These were very simple tasks and yet the autism group could not do them at the same time without their performance suffering substantially.

Most of everyday life entails multi-tasking. The teacher talks while she writes on the board. People speak words in combination with the tone of their voice, their facial expressions, their gaze, their gestures, and other body language. You listen to the person walking next to you while watching for the traffic in the street ahead. We are constantly managing large amounts of information and the associated allocation of processing resources. Individuals with autism have difficulty managing all of this incoming information. What we do almost without thinking about it, individuals with autism find incredibly challenging.

Though not directly tested in the dual-task study, speed of processing is also a variable that constrains the ability of individuals with autism to process information. Information processing capacity is restricted by the amount of information, of what complexity, in what period of time. Individuals with autism are renowned for having “one gear” that is a slower pace of work than others. This is another manifestation of constrained information processing capacity in this group.
A Lesson in Hidden Information Processing Demands

One of the first tests of language comprehension we administered was the Oral Directions subtest from the Detroit Test of Learning Aptitude (DTLA-2; Hammill, 1985). It begins simply with instructions such as “Touch the yellow circle” then becomes steadily more complex: “Before you touch the blue square, touch the green triangle” and then “Before you touch the red square, touch the purple circle, then touch the black triangle” and so on. Although high functioning individuals with autism could readily comprehend sentences of the same or longer length that had simple grammatical construction, they had substantial difficulty understanding sentences with complex grammatical construction. The question was why the difference when the number of words was the same. The answer was that the information processing demands were far greater when there were clauses and phrases. When there is a clause, the brain must process the meaning of the first part of the sentence and hold it in working memory, then process the meaning of the second part of the sentence, and then process the meaning of the first part in relation to the second part. The information processing demands are much higher for complex sentences. The language of daily life uses complex grammatical construction.

Even though the individuals with autism who participated in our studies spoke in complex sentences, they did not necessarily comprehend them when they spoke them or heard them spoken by others. And why was that? The reason was that clauses and phrases were often a single word to them. For example, in the movie The Rainman when Raymond refers to the seats in his deceased father’s antique car as “pitiful red,” this is a stereotyped phrase that is one piece to him not two separate words. For higher functioning individuals with autism, longer phrases and even sentences will become single encoded units that they don’t fully understand. Hence, it is very important to observe what individuals with autism understand by how they act – the demonstration of their understanding – and not take their words at face value. Many parents have complained, “I know he knows the rule. He says the rule while he is doing what the rule says not to do.” His actions demonstrate that although he says the words, he does not know what those words mean. The parent has made the mistake of thinking that saying equals understanding. “Doing” is the test of understanding, not saying.

The effect of increased processing demands can also be evident when individuals with autism are using expressive language. They may fail to integrate the intended message with the words and sentences that would clearly express their idea. When language is stored in chunks, those chunks must be used for spoken language, too.

The teachers were becoming very frustrated with Amanda. Day after day, she would repeatedly say, “Go swimming? Go swimming? Go swimming?” The teachers patiently told her that Tuesday was swimming day and today was not Tuesday. They showed her the weekly picture schedule with swimming clearly indicated under Tuesday. But nothing seemed to satisfy Amanda.
She persisted, “Go swimming? Go swimming? Go swimming? ” I was called in to try to find a way to get Amanda to understand what her teachers were trying to communicate to her. After observing the classroom routine, I had an idea of what the problem might be. I told the teachers that the next time Amanda began saying, “Go swimming?” answer as if she had said, “What’s next?” The teachers did as instructed and Amanda ceased her repetitive questioning. Swimming was Amanda’s favorite activity. Therefore, it had strong retrieval strength for her. Whenever Amanda tried to compose a message about a school activity, the language that came “on-line” was “Go swimming? ” What she really intended to say was “What are we doing next?”

Amanda’s language had to be analyzed according to its context rather than by its content. People with autism don’t always say what they mean and are dependent on their communication partners to carry the burden of interpreting their meaning.

Utility of the Complex Information Processing Concept

The complex information-processing concept is only of value to the extent it is of help with intervention and understanding behavior. Table 1 giving the intact and impaired abilities is an extremely useful guide for intervention in autism. Individuals with autism are generally operating on facts and rules. They need information conveyed succinctly with the fewest words possible. The bottom line needs to be stated – numerous examples should not be given in hopes that they will figure out the concept or bottom line.

One case makes the application of the utility of this profile immediately apparent:

Adam was a 27 -year-old young man who had been given a diagnosis of schizophrenia in early childhood although he had never had any signs of psychosis. He lived in a rural area and had a job in a department store that he had held for 10 years. One day Adam was fired when a comment he made to a female was interpreted as sexually harassing in nature. Adam then stayed in his apartment without any activities or supervision. Because he came from a religious family, he began watching evangelical shows and became preoccupied with sin and going to hell. Adam was found by his caseworker agitated, carrying a Bible, quoting passages about going to hell. He was admitted to a psychiatric unit. The psychiatric residents were concerned that Adam was manic and thought he should be tried on Lithium but Adam refused to comply. For Adam, Lithium was associated with an unpleasant experience: He had taken Lithium on June 7, 1978, and had gotten a stomachache. He went to the mental health clinic quite afraid he was poisoned and

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iii Diane L. Williams

iv This is a common misdiagnosis in verbal adults with high functioning autism or Asperger’s disorder.
was reprimanded for coming without an appointment. He grew more agitated and soon was in physical management on the floor with several men sitting on him. Of course he would not take lithium again after that experience! My advice was asked and I used what I knew of Adam’s thinking. Knowing he had autism, not schizophrenia, I told the resident, “There are two forms of the medicine. One is pink and one is blue. Put one in each of your hands and go in and ask which he took before. When he tells you, say ‘oh you took the bad pink/blue before and now you can take the good pink/blue.’” The psychiatric resident tried this and Adam complied and took the medication. The resident had tried reason when Adam’s brain worked on associative principles such as “pink = good” and “blue = bad.”

In a second case, Stephen, a man weighing 85 lbs. and near starvation was admitted to the psychiatric unit. The resident had tried every method to persuade him to eat to no avail. Persuasion involves insight and higher order language. When I met Stephen, it was 10:30 in the morning. He still had his breakfast tray and was staring at it and not eating. Through his ramblings, I gathered that his mother told him 40 years ago he was getting pudgy and he better watch what he ate. So he did, by staring at it. Then someone told him that “watching what you ate” meant not eating too much. However, Stephen was now depressed and had reverted to the earlier rule of watching what he ate by staring at his food. Understanding this, we established rules of the same type to restore his eating.

More About Complexity

Complexity is a general term or concept just like learning disability or mental retardation. It does not refer to one specific thing. Hence, a learning disability such as dyslexia is not defined absolutely as the inability to read a book, sentences or particular words. Reading ability or disability is defined relative to a person’s age and general level of function. Age appropriate tests and norms have been developed to make such determinations. At this point in research, we have defined impairments in information processing that disproportionately impact complex abilities as resulting in poorer performance relative to age- and IQ-matched peers and below standardized norms. For example, the motor impairment in the adult profile study was not only significantly worse than the control group but was in the moderately severe range of impairment according to clinical norms.

The term complexity can be articulated further. Various types of information can be complex. Information can be complex by virtue of its amount – small units but many of them such as a word list or branch points to be learned in a maze. Information can also be complex because of its inherent structure – a complex visual scene or a story with a theme. Information can be
complex because it is of multiple types and must be integrated. A good example of this is the need to integrate visual, vestibular, and position sense to maintain postural control. Another example of this type of complex information is the difficulty with skilled motor movements where individual motor actions must be integrated into a complex sequence that is greater than the individual parts. Information processing may also become complex because of time constraints, multiple simultaneous processing demands, or stress or anxiety. These factors are true for all individuals, but individuals with autism have a lower capacity and these factors become limiting far sooner than for age and IQ matched peers.

What Is In A Name?

Once the results of the cognitive and neurologic profile studies indicated an inherent deficit in autism with the processing of complex information, the question became what to call this profile – how to characterize it. Uta Frith had coined the term “central coherence” for a similar constellation of impairments in high order cognitive and language abilities and strengths on tasks that required perception of details, primarily visuospatial in nature. However, this term did not accommodate the sensory, motor, or memory impairments nor did it consider the expressive deficits. “Central coherence” was suited to explaining the problems with comprehension – the failure to make sense of things – but individuals with autism have equal difficulty with expression – prosody, facial expression, telling a logical story, detecting the inherent structure in material to remember it, or forming signs for sign language. They also had trouble with motor skills and disturbances in sensory perception. From a brain perspective, there was no “central coherer.” We therefore chose a descriptive terminology that was applicable to all impairments and the intact abilities and was standard to neurology and cognitive neuroscience. Therefore, the profile was characterized in terms of information processing.

The developmental neurobiologic analogue of these higher order human abilities is well known. It is referred to as neuronal organization of the refinement in brain circuitry that produces the abilities that are unique to human beings. Like the term, pervasive developmental disorder, information processing disorder has littler meaning without a detailed explanation. It fundamentally means the processes whereby the brain attaches meaning to information. The distinction between simple and complex information processing was based on the observation that within domains it was the highest order abilities that were impacted, whereas the basic abilities were spared. This pattern was unusual. If both simple and complex abilities had been equally affected, the result would have been a general deficit syndrome or general mental retardation. If only simple information processing would have been affected, the results would have been a selective language impairment or learning disability such as dyslexia; however, social skills, communication, eye contact, facial expression, insight and judgment would have been intact. Instead, unlike the general child neurology population, individuals with autism and autism spectrum disorders (ASD) have problems with higher order skills
across domains but do not have the visuospatial deficits or dyslexia common to the general child neurology patient group.

Once the concept of the selective impact on more difficult information with intact simple information is understood, the complex information processing construct becomes a functional foundation for intervention. It is important to keep in mind that the normal predictions regarding the status of higher order abilities based on the status of basic abilities no longer hold true in autism and ASD. Hence, it is common to over-estimate the language comprehension of individuals with autism and to use reasoning rather than facts when attempting to change their behavior.

**The Brain Basis of Thinking in Autism**

Until magnetic resonance imaging (MRI) and functional magnetic resonance imaging (fMRI) methods became available, the techniques for studying the brain in children with autism and for repeated studies were extremely limited. Computerized axial tomography (CAT) scans or positron emission tomography (PET) scans used to investigate brain disorders in adults involved radiation; thus, they could not be used in children or for repeated studies. Except for EEG or electroencephalographic techniques, which yielded brain waves, not brain images, the study of the brain in autism had to wait for the emergence of magnetic resonance imaging technology. The first application of this technology was for examination of the area or two dimensional measurements of specific brain structures (Cody, Pelphrey, & Piven, 2002). With time, the computer programs and analyses were developed for three dimensional measurements that led to more accurate volume measurements (e.g., Aylward, Minshew, Field, Sparks, & Singh, 2002; Courchesne et al., 2001; Sparks et al., 2002). The next breakthrough, and most significant one for autism, was in the development of functional MRI methods by which the activity of the brain during performance of a motor or cognitive task could be recorded. This became the first true window on the thinking brain in autism. Most recently, diffusion tensor tracking methods were allowing the mapping of white matter pathways, which contain the nerve cell fiber connections underlying information processing between brain regions.

An fMRI study of sentence comprehension in 17 adolescents and young adults with high functioning autism and 17 normal controls found the first of many important differences in brain function in autism (Just, Cherkassky, Keller, & Minshew, 2004). Compared to the control group, the autism group displayed: 1) increased brain activation in the word region of the surface gray matter; 2) reduced brain activation in the surface gray matter area that processes the meaning of sentences; 3) reduced functional connections or correlations among the pairs of cortical regions that participate in language function; and 4) reduced synchrony between the activity of the region pairs. When the functional connectivity was plotted for all regions’ pairs for the autism group and the control group, the line joining the points for the autism group was parallel to, but below the line joining the points for the control group, suggesting that the brain was organized the same but did not achieve the same degree of connectivity in the autism group as the control group.
This type of fMRI study of individuals with high functioning autism has been repeated using tasks that involve problem solving (Just, Keller, Cherkassky, Kana, & Minshew, 2006), social thinking (Kana, Keller, Williams, Minshew, & Just, 2005), and inhibiting context inappropriate behavior (Kana, Keller, Minshew, & Just, 2006). The results in all cases have been similar, with differences reflective of the type of cognitive task, suggesting a common principle of underdevelopment of the connectivity of the neural systems for autism.

In the brain, higher order abilities are supported by neural systems of the collaboration of many brain regions to enable a more complex ability to occur. This is analogous to the collaboration that must occur between the driver, the steering mechanism, the engine, the drive train, and the axel to accomplish driving a car. The fMRI studies completed to date suggest that the neural systems of individuals with autism have fewer and smaller centers to call upon and less flexibility in doing so. Hence, when the environmental demands change and different abilities are needed to address these demands, the brain in autism has less flexibility and fewer and smaller resources to draw upon. In addition, the brain regions are not working in synchrony or harmony. In summary, fMRI studies are making a substantial contribution to our understanding of the brain basis of thinking, its differences and its limitations in autism. These can be used to guide intervention.

Compensatory Strategies

The fMRI studies have also revealed that individuals with autism use different cognitive approaches to tasks, differences that are not apparent from their behavioral performance. Their approach will ultimately impact their capacity – imposing limits or raising them – depending on the nature of the task. In the sentence comprehension study (Just et al., 2004) described above, it was clear that individuals with autism focused on the words of the sentences rather than the meaning of the entire sentence. Their behavioral performance was the same but the task was simple. It was not apparent from looking at the behavioral results that the individuals with autism were processing language differently.

A second fMRI study with a different type of task, demonstrated the use of another type of compensatory strategy by the individuals with autism. The task was a classic measure of working memory called an n-back task. In this task, the individuals asked to monitor a string of letters presented one at a time for those that are the same when they appear two in a row (1-back) or separated by one different letter (2-back). Both the autism group and the normal control group performed similarly on this task with respect to the behavioral results. However, the fMRI results suggested that the autism group viewed the letters as graphic figures and did not decode them into letter names as the control group appeared to do (Koshino et al., 2005). Hence, the normal control group displayed brain activation in the left executive and left language areas of the brain, whereas the autism group displayed brain activation in both posterior visual areas and the right executive area. In essence, these results indicate that individuals with autism rely on lower-level visual abilities rather than higher-
level abilities to perform certain tasks. Had this task involved Russian letters rather than English letters, the controls would likely have performed very poorly and the autism group would have performed much better because the strategic use of language would not have been as readily available.

The implications of the results of the working memory for letters study are that reliance on visual abilities can be a strength or a limitation depending on the task. This knowledge can be used in job placement. Jobs such as laying tile straight, analyzing satellite surveillance maps, or screening luggage or other import containers coming into the country might be potential careers for individuals with ASD that would draw on their tendency to process information visually and to perceive details.

Another study added further insight into this issue. This study involved the use of mental imagery during sentence reading (Kana, Keller, Cherkassky, Minshew, & Just, 2006). In this study, a high functioning autism and matched control group were presented with low imagery sentences (Addition and subtraction are mathematical operations) and high imagery sentences (There was a rainbow over the corn field). The fMRI study showed that the control group activated the imagery area of the brain only for the high visual imagery sentences. In contrast, the autism group activated the imagery area of the brain for both low and high visual imagery sentences. Hence, individuals with autism appeared to think in visual pictures presumably to enhance comprehension. This may not be true of all individuals with autism. Some may think in words rather than pictures. Studies like this of a much larger number of individuals with autism are needed to determine if there are different types of thinkers as Dr. Temple Grandin suggests.

The question becomes what happens when material cannot be visualized. For example, how do people with autism visualize words that are abstract like justice or honor? Dr. Temple Grandin has written about her experiences with visual thinking. For abstract words like justice, she thinks of episodes of Law and Order. This dependence on already experienced situations or visual pictures, e.g., concrete examples, for comprehension highlights the limitations of comprehension even in more able individuals with autism. It also highlights the compensatory use of visual strategies for performance of many tasks that are typically performed with language or executive processes. It is important to remember that not all individuals with autism are visual thinkers and that some likely think in words.

Using visual strategies, either pictures or written words, to communicate instructions or messages to individuals with autism serves to reduce the amount of content and compress the content to essential information. The format of these instructions should follow a Campbell Soup format for maximum effectiveness. As seen above, clauses and phrases add processing demands that individuals with autism may not be able to negotiate. Unnecessary words should be eliminated and only essential facts should be included. Individuals with autism would greatly benefit from the software programs that extract key points from textbooks and class notes and eliminate nonessential information, clauses and phrases.
Origin of the Brain Differences

Neuroimaging studies are providing increasing evidence of the brain differences in individuals with autism, but where do these brain differences come from? Autism is currently thought to have multiple levels of causation that are assumed to originate in abnormalities in the genetic code that controls what will happen later in brain development (Rutter, 2005). Autism is a disorder that starts in utero but is only identified as development unfolds during the first years of life. The abnormal mechanisms of brain development are realized as structural and functional abnormalities of the brain. These abnormalities are seen as cognitive and neurological abnormalities that are ultimately manifested as behavioral differences. Thus, the behavioral differences that characterize the disorder we call autism result from underlying biological differences. Individuals with autism learn and act differently because their brains function differently. The environment can influence their learning but cannot change the underlying neurophysiological differences (not yet). Individuals with autism cannot control the way they think about the world, but we can understand better how their brains handle information. This understanding will help us to design interventions that help the brains of individuals with autism handle increasing processing challenges of load and complexity of task.

Memory and Learning

Impairments of memory and learning are not included in the list of diagnostic criteria for autism or autism spectrum disorder but have been documented in autism in the profile of neuropsychologic functioning. These impairments have significant implications for the way in which individuals with autism learn and, by inference, for the teaching strategies that are most appropriate for this population.

In a comprehensive study of verbal and visual information of a wide range of complexity in 52 high functioning adolescents and adults with autism and 40 group-matched normal controls, Minshew and Goldstein (2001) found that basic memory abilities were intact but that the capacity to learn and remember deteriorated as the complexity of the information increased. Impairments were found if the amount of information of a single type was large or if the inherent structure of the visual or verbal information were complex. A maze-learning task documented the relationship between increasing complexity of the material and progressively worse memory impairments in the autism group. As the mazes became increasingly complex, the performance of the autism group became progressively worse relative to the controls.

In essence, the autism group had memory difficulty in both the auditory and visual domains. The predictive factor for difficulty was not whether it was auditory or visual. Rather, difficulty occurred in both modalities if the material to be learned or remembered required a cognitive organizing structure or required the detection of organizational principles inherent to the material (Minshew & Goldstein, 2001). The flip side of this impairment was that learning and memory could be improved by presenting material to be learned
or remembered in small chunks or by simplifying it (preprocessing it by providing the bottom line rather than providing examples from which the principle was to be extracted). In addition, memory and learning could be improved if increased time was provided or if the material remained in sight for rehearsal at the individual’s own pace.

The implications of these findings are two. The first is again that the involvement of the brain in autism extends beyond the diagnostic triad and there is a need to redefine this syndrome in DSM-IV and ICD-10. The second is that the brain involvement in autism extends not just to the underdevelopment of connections within neural systems but also to connections between neural systems. The observed impairment in memory and learning relates to the use of concepts and language in the service of memory and thus depends on interactions and connections between the memory, language, and reasoning systems of the brain.

**Generalization of the Construct to More Impaired Individuals with Autism**

The findings presented in this chapter are based on the study of verbal individuals with IQ scores primarily above 80 who were between the ages of eight and 55 years of age. The requirements for the participants to be verbal, over the age of eight and to be non-mentally retarded was based on the need for the capacity to complete the large number of tests to reveal the pattern of intact abilities and impairments and the ability to cooperate during functional imaging. We also wanted to match the participants with autism with a typically developing or normal IQ group. An IQ score below 80 made it impossible to find typically developing children or normal adults who matched. Mental retardation has a variety of causes each with its own cognitive signature. Thus, the presence of mental retardation presents a confound when looking for group differences unique to autism. Using mental age matched younger children creates age disparities that present another confound when studying a developmental disorder. The use of individuals with autism with IQ scores in the average range allowed us to identify the cognitive and brain features that were unique to autism and not attributable to mental retardation.

The study of a subgroup rather than a representative sample of the entire population of individuals with a disorder is a well accepted scientific approach for establishing essential features of a disorder that apply to the entire disorder. The justifications for the extrapolation to the entire disorder are based on the assumptions that all individuals have the disorder in question and that the disorder has a common pathophysiology. All evidence to date supports autism as being a single disorder of wide severity. Severity in and of itself has never

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vi Pathophysiology should be distinguished from etiology. Pathophysiology refers to the mechanism of expression within the brain—the brain structures affected and the way in which they are affected. Etiology refers to the way in which this pathophysiology is triggered. There can be many different triggers for the same pathophysiology. If autism was not assumed to have a common pathophysiology, there would be no justification for any of the scientific studies conducted. That is if every case of autism has a totally different brain basis then there would be no rationale for studies of groups of participants that look for a common finding or difference between those with autism and those without.
been a justification for dividing a disorder into different conditions. Perhaps the most striking evidence of the commonality between low and high functioning autism is the co-occurrence of high and low functioning cases within the same families and even within twin pairs (Le Couteur et al., 1996). Other evidence is the shared neuropathology, family history and severity of presentation in the early years (Rutter, 2005).

The question then becomes how the findings apply to those with autism who were not tested, e.g. those who were lower functioning by virtue of age or IQ. We cannot directly address that question because those individuals were not tested since they cannot consistently cooperate for formal neuropsychological or fMRI procedures. Theoretically, as described in the following section, the information processing capacity is progressively truncated to the point that no meaning is attached to sensory information and there is no functional connectivity within the brain to attach meaning to sensory information.

**Mental Retardation in Autism is Not a Separate Diagnosis**

It is common practice for low functioning individuals with autism to also receive a diagnosis of mental retardation as though there were two co-occurring diagnoses rather than a modifier to indicate level of function. As the severity of autism increases, information processing capacity falls rapidly and the predicted consequence is mental retardation bearing the hallmarks of the cognitive profile in autism – disproportionate impairments in higher order sensory, motor, memory and learning, language, and abstraction abilities with preservation of elementary abilities in the same domains. When autism is at its most severe, there is essentially no capacity to attach meaning to sensory information but there is no blindness or deafness, nor is there cerebral palsy. This progressive reduction in information processing capacity with preservation of the autism profile (disproportionate impact on higher order abilities and preserved simpler abilities) presents as mental retardation. In actuality, it is part and parcel of the cognitive impairment typical of autism. The profile is present at all levels of function in autism – in verbal individuals it may be characterized as a learning disability, whereas in low functioning individuals it is characterized as mental retardation. The brain basis of this cognitive profile is a reduction in the functional connections between the brain regions needed to perform tasks. In general, the brain in autism has fewer processing subregions and deploys them less flexibly to address task demands than normal controls.

**Implications of the Brain Basis of Autism**

Expectations for an individual with autism cannot be based on an “intelligence score.” There is a disconnection between IQ score and adaptive functioning in autism. In other words, IQ does not predict adaptive functioning
in autism. Individuals with autism will not demonstrate the same level of common sense or problem solving ability as age peers of a similar level of intelligence. So, they can’t “act their age.” Therefore, more immature behaviors should be expected from individuals with autism no matter what their overall cognitive functioning level is. A child with autism may be placed in a classroom with other fifth graders because he can do fifth grade level academic work. However, his social behavior may be more like that of a kindergarten age child. This should not be cause for alarm from the teaching staff, but should be an expected and planned for consequence of the developmental disorder of autism. We see severe social and emotional immaturity persist into the adult years. For example, we know a middle age woman with autism with an above average IQ. However, she speaks of buildings as if they are “hunks” and talks about going on dates with them. If you close your eyes, you would think you are talking to a preadolescent with a crush on the latest boy band. She has combined her obsession with buildings and an adolescent or younger crush.

If an individual with autism is not doing something, they are not being “uncooperative,” they are just reacting to the biological response of their body. As human beings, we do the things we are good at and feel comfortable with and resist doing things we find difficult. However, typical people use executive functions to override this basic tendency. If we don’t do this, we are going to get fired and if we get fired, we can’t make our house payment. So, we talk ourselves into doing what we would otherwise resist. Individuals with autism don’t necessarily have the executive function, decision-making process to override their initial tendency to resist doing a hard or unpleasant task, and they do not respond to social consequences in the same way that individuals without autism do. Consequently, they are very unlikely to do something they judge to be difficult. It doesn’t matter if this judgment is an accurate assessment or not. The fact that the individual with autism is resistant means that they perceive the behavior as being hard or unpleasant for them. The challenge is then to figure out why they think the task is hard and to change the task so that the individual with autism can do it.

Because individuals with autism can’t change the way they think and perceive the world, changes have to be made to accommodate them. Previously autism was considered a “psychological” problem. Underlying this label was the notion that it had no connection to the brain; that it was in the “mind.” Individuals with psychological problems are assumed to have some control over their actions, i.e., if you wanted to act differently you could. As discussed above, we have a much better understanding of the brain-behavior connection in autism. Unfortunately, many people still hold to the idea that autism is a “psychological” problem that individuals choose to give into. For example, if a child with autism has already done a task and refuses to do it again, a teacher is likely to say, “He can do it. He just won’t.” The reason for the child’s inaction may be because the environment has changed so that he doesn’t recognize it as the same task. It may be that he does not understand what is expected of him. It may also be that he is thinking, “I’ve already done it, why should I do it again?” The child with autism reacts in a certain way because of the information his brain gives him about the situation. He does not do it to be uncooperative or to create problems for the teacher. To get the child to do the
task, the teacher must use her perceptive skills to try to determine what is a likely interpretation of the child’s behavior and make changes so that the child will respond.

The Future in Intervention with Individuals with Autism

The current work in neuropsychological and neuroimaging research is greatly advancing our understanding of the brain-behavior connection in autism. The motivation for the continuance of this work is the eventual development of cognitive interventions that will promote the growth of underdeveloped brain circuitry and higher-level skills in individuals with autism. While such interventions are still to be developed, it is our hope that teachers will use the current level of knowledge as the basis for the creation of intervention programs that accommodate but also challenge the brain development of individuals with autism.

Tips For Teachers

1. Because individuals with autism cannot process large amounts of information efficiently, the amount of information presented to them needs to be reduced. Rather than expecting him to learn large amounts of detail (something he may actually do at the expense of learning the main idea of the material) you should ask, “What are the main points he needs to learn from a lesson?” and focus on that material instead.

2. Because individuals with autism have difficulty organizing material or recognizing an implicit organization, you need to “preprocess” the information by highlighting and presenting it with an explicit organization.

3. Because individuals with autism process language/information differently, they do better with language/information that is clear and concise – this reduces the processing load. They also do better when given more time to process language/information.

4. Be careful about asking an individual with autism to do several demanding tasks at once. For example, he cannot think of what to write and how to write it at the same time. Writing in stages may be more helpful – that is, brainstorm the idea, write the key words needed to express the idea, and then put the key words into sentences.

5. You can’t use the level of expressive language of individuals with autism to gauge the level of language input. Expressive output may represent unanalyzed language that has been learned and stored as large chunks. Therefore, you should gauge the appropriateness of your language level by the response of the child or adult with autism.

6. Even though a person with autism may be able to do a task, you don’t know what cognitive resources they are using. Therefore, they may not be able to do a task if you increase its complexity. Remember what is complex is defined individually and situationally.

7. Persons with autism can do some visual processing better than auditory processing because it is reduced dynamically. They may have difficulty with
visual processing if it is dynamic or complex, demanding more than one cognitive process or coordination of different processing areas across the cortex.

References


